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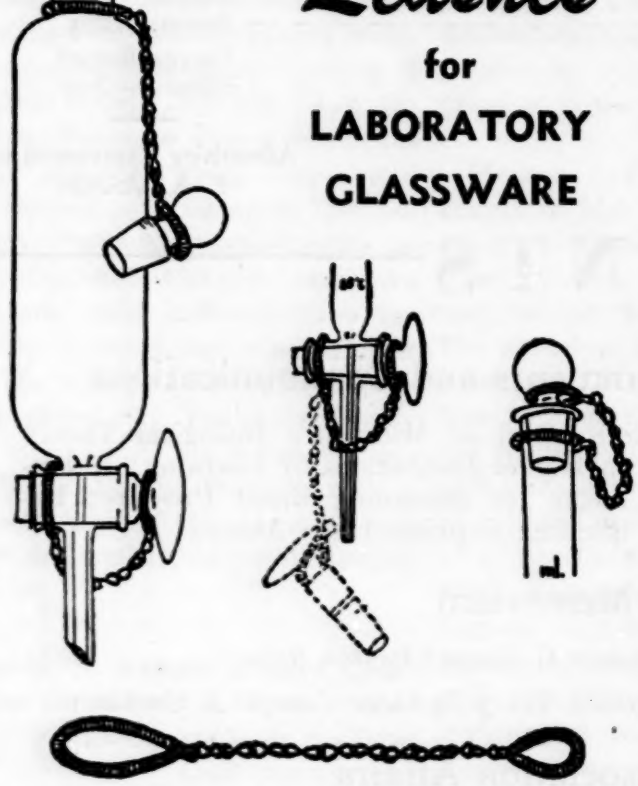

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The History of Oxygen

Malcolm Dole
Department of Chemistry, Northwestern University

TO A CHEMIST, OXYGEN IS ONE of the most interesting elements of the earth because of its remarkable reactivity, its paramagnetism, its participation in living processes, its use as the standard for atomic weights, and, finally, its great abundance in the earth's crust. The origin of oxygen not only as an element, but as a free gas in the earth's atmosphere, and the sequence of events which oxygen now undergoes as it passes through the carbon and other cycles, constitute the history of oxygen, a subject about which we may never know with certainty all of the details, although the broad aspects of some of its history seem at the present time to be clear.

The three stable isotopes of oxygen, masses 16, 17, and 18, presumably were initially formed from the primordial flux of neutrons (called by Alpher the "ylem") which was the precursor of all matter. Alpher, Bethe, and Gamow (*1*) have recently published a neutron-capture theory of the formation and relative abundance of the elements which makes plausible, from a semiquantitative point of view, the idea that all the elements were initially formed in the same event, by the decay of neutrons to protons and electrons and by the capture of neutrons and protons by each other to form the various known nuclei. Given the formation of oxygen by this mechanism, we now proceed to discuss the history of oxygen on our own planet.

A problem which challenges our imagination is that of explaining the existence of free uncombined oxygen in our atmosphere. D. ter Haar (*12*) has recently reviewed theories of the origin of our solar system and presented a new modified theory of his own which comes the closest of all extant theories to explaining quantitatively the known facts. He starts with the simplest possible hypothesis, originally proposed by Kant, namely, a sun surrounded by a gaseous envelope. Condensation nuclei formed near the sun will be inorganic compounds of heavy elements (that is, heavier than hydrogen and carbon); hence the inner planets will be small and dense. They will have acquired their size before gravitational capture of matter from the gaseous envelope has become important. The outer planets, however, would be formed in a relatively cold region of the envelope so that organic as well as inorganic compounds could form and condense. The outer planets, therefore, will be of small density, but will grow to large size because of gravitational capture.

During the process of condensation, the earth seems to have lost practically all of the light elements which could not be bound chemically; for example, as Unsöld (*24*) has pointed out, in the star τ Scorpii, neon and nitrogen are about equally abundant, and their abundance does not fall much short of that of oxygen, whereas in the earth's atmosphere the abundance of neon is almost negligible. If neon of atomic weight 20 could not be held by the earth, neither could water vapor of mass 18, nor atomic oxygen of mass 16. Argon of mass 40 and molecular oxygen of mass 32 would be much more likely to be captured. However, because of the reactivity of oxygen it is almost inconceivable that the earth's atmosphere when first formed could have contained this element in its uncombined state. Water must have been held in combination with inorganic compounds, most of which are readily hydrated or which adsorb water to some extent. As the matter condensed to create the earth, the potential energy of the gaseous envelope was undoubtedly transformed into heat, raising the temperature of the growing nucleus. Inasmuch as the melting point probably rises more rapidly with the pressure in the interior of the earth than does the temperature, the earth would solidify first within, followed by a gradual consolidation proceeding outward (see discussion in *29*). This heat would cause water to be driven out, but if the planet had accumulated enough mass at this point, the water would be held in the gravitational field. In 1924 Tammann (*23*) calculated that even at as high a temperature as 1,500° K the fraction of water molecules having velocities equal to or greater than the "escape velocity" was only 1.4×10^{-75}, a negligible fraction. Nitrogen and carbon dioxide would collect in the atmosphere on being driven out of the hot magma, in much the same way as water. In addition to being fixed in water and carbon dioxide, we find oxygen in the earth's crust also in the form of oxides and silicates, but we shall not be concerned here with the history of oxygen in these compounds.

We come now to the period of oxygen's history beginning with the earth after it had cooled from its original molten state. The most important fact that

Adapted from an address delivered as the retiring president of the Northwestern Chapter of Sigma Xi, October 20, 1948.

confronts us is the present existence of oxygen in the atmosphere; there are those, such as the Russian biochemist Oparin (*18*), who believe that life was first created on the earth by processes not involving free oxygen, such as the slow formation in the oceans of small organic molecules, then larger polymers, then colloidal particles, such as tactoids or coacervates, and finally living organisms. These living organisms then began to photosynthesize, thus creating the oxygen of the atmosphere by the dehydrogenation of water. The difficulty with this theory of Oparin's is that it cannot be checked by the application of known physicochemical principles, because of our present ignorance concerning not only the mechanism of the origin and production of life, but also of the details of the photosynthesis process. Tammann (*23*) believed that oxygen arose through the thermal dissociation of water followed by escape of hydrogen from the atmosphere, but for this process to have been significant the temperature of the water vapor must have exceeded 1,500° K (to produce appreciable dissociation).

In the higher regions of the earth's atmosphere, in the stratosphere, the ultraviolet light from the sun is much more intense than at the earth's surface, producing at a height of 25 km a maximum in the partial pressure of ozone, according to the photochemical reaction

$$O_2 + h\nu \rightarrow O_2^* \rightarrow O + O \qquad (+5.08\ ev) \qquad (1)$$
$$O + O_2 + M(N_2?) \rightarrow O_3 + M \qquad (-1.03\ ev) \qquad (26)$$

(Reaction numbers are those of Table 1.) It is this layer of ozone which prevents practically all of the light of wave length shorter than about 3,000 A from reaching the earth. But above 50 km very little ozone is present, so that we may assume that in this region of the stratosphere and at higher levels in the ionosphere, the gas present is exposed to solar radiation of wave length even as short as 600 A. It is important to consider possible photochemical as well as ionization processes which may have given rise to free atmospheric oxygen as suggested by Poole (*19*). In Table 1 we have listed all of the processes, photochemical or ionic, which are believed to exist or to be capable of existing in the stratosphere or ionosphere. It is a relatively simple matter to write a sequence of reactions which can produce oxygen; for example, water and oxygen on dissociation produce fragments which could react as follows:

$$H_2O + h\nu \rightarrow H + OH \qquad +5.12\ ev \qquad (12)$$
$$O_2 + h\nu \rightarrow O + O \qquad +5.08\ ev \qquad (1)$$
$$O + OH \rightarrow O_2 + H \qquad -0.69\ ev \qquad (22)$$
$$OH + OH \rightarrow H_2O + O \qquad -0.61\ ev \qquad (9)$$

or

$$OH + OH \rightarrow H_2 + O_2 \qquad -0.69\ ev \qquad (14)$$

If the hydrogen of reactions 3, 17, and 19 has thermal energies greater than 1,000 or 1,500° K, it will be quickly lost, leaving an excess of free oxygen in the atmosphere. Poole (*19*) has estimated that, at a tem-

TABLE 1

POSSIBLE PHOTOCHEMICAL AND IONIC PROCESSES OF THE STRATOSPHERE AND IONOSPHERE*

Reaction No.	Reaction	Energy absorbed (+) or liberated (−) in ev	Reference
	Endothermic Photochemical Reactions		
1.	$O_2 + h\nu \rightarrow O + O$	+5.08	(13)
2.	$O_2 + h\nu \rightarrow O\ (^1D) + O$	+7.05	(10)
3.	$H_2O + h\nu \rightarrow H + OH$	+5.12	(13)
4.	$N_2 + h\nu \rightarrow N + N\ (^2D^o)$	+9.75	(17)
5.	$CO_2 + h\nu \rightarrow CO + O\ (^1D)$	+7.47	(17)
6.	$CO + h\nu \rightarrow C + O$	+9.14	(13)
	Endothermic Ionizing Reactions		
7.	$O_2 \rightarrow O_2^+ + e$	+12.2	(22)
8.	$O_2 \rightarrow O + O^+ + e$	+18.65	(22)
9.	$H_2O \rightarrow H_2O^+ + e$	+12.7	(22)
10.	$H_2O \rightarrow H + OH^+ + e$	+18.4	(15)
11.	$H_2O \rightarrow H + H + O^+ + e$	+23.1	(15)
12.	$H_2O \rightarrow H_2 + O^+ + e$	+18.6	(15)
13.	$N_2 \rightarrow N_2^+ + e$	+15.51	(22)
14.	$CO_2 \rightarrow CO_2^+ + e$	+14.4	(22)
15.	$CO_2 \rightarrow CO + O^+ + e$	+19.1	(22)
16.	$CO_2 \rightarrow CO^+ + O + e$	+19.6	(22)
	Exothermic Thermal Reactions		
17.	$OH + O \rightarrow O_2 + H$	−0.69	(2)
18.	$OH + OH \rightarrow H_2O + O$	−0.61	(2)
19.	$OH + OH \rightarrow H_2 + O_2$	−0.69	(20)
20.	$N\ (^2D^o) + H_2O \rightarrow NH + OH$	−0.7	
21.	$N + H_2O \rightarrow NO + H_2$	−0.31	
22.	$N + OH \rightarrow NO + H$	−0.95	
23.	$N\ (^2D^o) + OH \rightarrow NH + O$	−1.43	
24.	$N\ (^2D^o) + CO_2 \rightarrow NO + CO$	−2.2	
25.	$N + O_2 \rightarrow NO + O$	−0.21	
26.	$N + NH \rightarrow N_2 + H$	−3.98	
27.	$C + H_2O \rightarrow CO + H_2$	−4.16	
28.	$CO + H_2O \rightarrow CO_2 + H_2$	−0.52	
	Exothermic Thermal Reactions Requiring a Third Body (Possibly N_2)		
29.	$O + O_2 \rightarrow O_3$	−1.03	(22)
30.	$O + H \rightarrow OH$	−4.34	(8)
31.	$OH + OH \rightarrow H_2O_2$	−2.2	(27)
32.	$N + N \rightarrow N_2$	−7.38	(13)
33.	$N + O \rightarrow NO$	−5.29	(13)
34.	$N + H \rightarrow NH$	−3.4	(13)
35.	$N + C \rightarrow CN$	−5.96	(13)
36.	$C + H \rightarrow CH$	−3.47	(13)
	(Also the reverse of reactions 1, 3, 5 and 6)		
	Exothermic Ionic Processes		
37.	$O_2^+ + e \rightarrow O + O$	−7.11	
38.	$N_2^+ + e \rightarrow N + N$	−8.12	
39.	$H_2O^+ + e \rightarrow H + OH$	−7.6	
40.	$OH^+ + e \rightarrow H + O$	−9.0	

* All atoms and molecules listed are gaseous and in their ground states unless otherwise indicated. All atoms and molecules are composed of the most common isotope (slight differences will exist if hydrogen, H^1, is replaced by deuterium, for example).

erature of 1,000° K, the ionosphere will lose all of its hydrogen in five years; if the hydrogen exists as atomic rather than molecular hydrogen, the time of escape is reduced from five years to two days. For every two atoms of hydrogen lost, the atmosphere will show a net increase of one oxygen atom gained.

It will be noted that reactions 17, 18, and 19 are all bimolecular and give rise to two products, and thus do not require a "wall" or a third body for conservation of momentum; in other words, they are homogeneous reactions. However, reactions 18 and 19 can probably be ruled out as being of minor importance because the relative amount of water present is smaller than that of oxygen. As a consequence, the partial pressure of OH will be smaller than that of atomic oxygen, and the probability of a collision between OH and O will be greater than the probability of a collision between two OH radicals. Dobson, Brewer, and Cwilong (*4*), who have made careful measurements of the frost point in the stratosphere up to heights of about 10 km, point out that the humidity content of the stratosphere, which drops off rapidly when the stratosphere is reached, is less than expected. The water content of the upper stratosphere and ionosphere is unknown. Elvey (*9*) states, however, that the spectrum of the nonpolar aurora (light of the night sky) demonstrates in the upper atmosphere the presence of water molecules in certain excited states along with oxygen, and sodium atoms, N_2, NO, and O_2 molecules.

For hydrogen atoms or molecules to have velocities equal to the escape velocity as calculated by Jeans (*14*) their velocities must be equivalent to temperatures of several thousands of degrees (at 1,500° K the fraction of hydrogen molecules, assuming a Maxwellian distribution, which have velocities equal to or greater than the escape velocity, is 0.00032, (*23*). Is there any mechanism by which hydrogen atoms or molecules can acquire such high energies? In reaction 17 which we favor as the oxygen-producing reaction, the energy liberated is 0.69 ev; if this excess energy is dissipated as translational energy the fraction 32/33, or 0.67 ev, will be carried by the hydrogen atom. This is equivalent to a "temperature" of about 5,000° K. Such a "hot" molecule will soon reach thermal equilibrium by collisions with the gases at the level of the stratosphere at which it is formed because the molecular mean free path is negligible in comparison to stratospheric distances at the pressures of 10^{-3} to 10^{-5} mm Hg existing in the stratosphere. As greater heights are reached, the pressure drops and the temperature rises. Thus, at a height of 285 km Godfrey and Price (*11*) estimate the temperature to be 1,350° K and the pressure, 6×10^{-8} mm Hg. At this temperature the hydrogen would be rapidly lost as mentioned above. At the present time the rate of vertical mixing between layers of the stratosphere and the ionosphere is unknown, hence it is impossible to estimate the rate at which the hydrogen escapes from the stratosphere. Certainly there is a negligible abundance of hydrogen in the upper atmosphere, in contrast to earlier ideas. Wildt (*30*) points out that only about 1 per cent of the helium formed by radioactive decay in the earth's sedimentary rocks is present in our atmosphere; the rest "must have escaped from the atmosphere during geological time." Hydrogen presumably would escape even more rapidly than helium.

In addition to reactions 3 and 17 as a source of oxygen, the following series of reactions could conceivably result in the presence of free atmospheric oxygen:

$CO_2 + h\nu \rightarrow CO + O$	+ 5.5 ev	(*23*)
$CO + h\nu \rightarrow C + O$	+ 9.14 ev	(*18*)
$N(^2D^\circ) + H_2O \rightarrow NH + OH$	− 0.7 ev	(*11*)
$N(^2D^\circ) + OH \rightarrow NH + O$	− 1.43 ev	(*5*)

These reactions do not require atomic oxygen for the production of O_2 as does reaction 17. Although Dhar (*3*) states that formaldehyde has been found in rain water, reactions producing it have not been listed in Table 1 because formaldehyde is rapidly decomposed photochemically, particularly in the presence of oxygen (*17*). Table 1, however, does contain an amazingly long list of reactions and demonstrates the richness of the chemical processes in the upper atmosphere. The energy for the ionization of molecules can be thought of as coming from cosmic rays; evidence for ionization is, of course, the free electron and ion content of the ionosphere.

So much for the past history of the origin of oxygen, as far as we can infer it from modern knowledge. What about the present oxygen of our atmosphere, does it have a history? The universally accepted belief is that all of the oxygen of the atmosphere has been produced by the photosynthesis process in land and marine plants, mostly from photosynthesis in the oceans of the world. There is one small difficulty with this theory—the isotopic composition of atmospheric oxygen is not that of oxygen in the water of the oceans as discovered by the author (*5*). Ruben, Randall, Kamen, and Hyde (*21*) demonstrated that the oxygen produced by photosynthesis came entirely from the water and not from the carbon dioxide of the culture medium, while Dole and Jenks (*6*) showed that the photosynthetic oxygen had the expected isotopic composition for isotopic exchange equilibrium between oxygen and water, a composition which is definitely lower in O^{18} content than that of atmospheric oxygen. The present oxygen of the atmosphere

must have an origin different from photosynthetic oxygen or the photosynthetic oxygen must have changed its composition by isotopic exchange after being produced photosynthetically. Before we give up the century-old belief in the importance of the photosynthetic origin of oxygen, let us investigate the possibility of O^{18} enrichment of atmospheric oxygen by isotopic exchange.

There are two possible exchange reactions which could enhance the O^{18} content of atmospheric oxygen; the first,

$$2H_2O^{18}(g) + O_2{}^{16}(g) \rightleftarrows 2H_2O^{16}(g) + O_2{}^{18}(g),$$

and the second,

$$2H_2O^{18}(g) + CO_2{}^{16}(g) \rightleftarrows CO_2{}^{18}(g) + 2H_2O^{16}(g),$$

followed by the irreversible reaction

$$CO_2{}^{18}(g) + O_2{}^{16}(g) \rightarrow CO_2{}^{16}(g) + O_2{}^{18}(g)$$

Urey (*25*) has recently recalculated, at 0° C and above, the equilibrium constants of these reactions first published by Urey and Greiff (*28*). Values for the fractionation factor, which is the ratio of O^{18} to O^{16} in the oxygen or carbon dioxide divided by the similar ratio for the water in the two equilibria at different temperatures, are shown in Table 2 for the oxygen-water and oxygen-carbon dioxide equilibria. We have extended Urey's calculations to −50° C in the case of the oxygen-water vapor equilibrium.

TABLE 2

FRACTIONATION FACTORS FOR THE WATER-OXYGEN AND WATER-CARBON DIOXIDE ISOTOPIC EXCHANGE EQUILIBRIA

Reaction	223°K	273.1°K	298.1°K
Water vapor-oxygen	1.030	1.017	1.014
Water vapor-carbon dioxide ..		1.055	1.047
Liquid water-oxygen		1.006	1.006
Liquid water-carbon dioxide ..		1.044	1.039

Note that the fractionation factors for the oxygen-water equilibria are much smaller than those for the carbon dioxide-water equilibria and have a practically zero temperature coefficient in the case of the equilibrium between oxygen gas and liquid water. Letting α represent the fractionation factor, the percentage increase in the O^{18} abundance of the oxygen when brought into equilibrium with liquid water (assuming that both the free oxygen and the oxygen in water had the same isotopic composition before being brought into isotopic exchange equilibrium with each other and assuming an infinite volume of water) is $100\ (\alpha - 1) = 0.6\%$ or 6 parts per mil at 273° K. Atmospheric oxygen has an O^{18} content 30 parts per mil greater than the oxygen of Lake Michigan water. Even assuming that the exchange equilibrium is established at 221° K and that the water vapor participating in the equilibrium at this low temperature eventually established an equilibrium with ocean water at 10° C so that the over-all process can be written

$O_2{}^{16}$ (stratosphere at −50° C) + $2H_2O^{18}$ (ocean at 10° C) ⇄ $O_2{}^{18}$ (stratosphere at −50° C) + $2H_2O^{16}$ (ocean at 10° C),

the O^{18} content of free oxygen will be enhanced 20 parts per mil with reference to ocean water or 25 parts per mil with respect to Lake Michigan water, still less than 30 parts per mil.

Dole and Roake (*7*) have shown, furthermore, that oxygen isotopes do not exchange between oxygen gas and water vapor when passed through a glow discharge at low temperatures and pressures. An exchange of oxygen isotopes could be demonstrated, however, between carbon dioxide and oxygen, so that the enhanced O^{18} content of the atmosphere can be fully and quantitatively explained by the following sequence of reactions:

CO_2 (air) + H_2O (vapor at 0° C) → CO_2 (air) of O^{18} content equal to 49 parts per mil (Lake Michigan standard).

This CO_2, having an O^{18} content enhanced to 44 parts per mil with respect to ocean water, then undergoes an irreversible and random exchange of its oxygen isotopes with the oxygen of the stratosphere by virtue of reactions 1, 3, 5, 6, 17, and 19 of Table 1 or their reverse, producing in the stratosphere an O^{18} content enhanced to the maximum extent of 44 parts per mil with respect to ocean water. The observed value is 30 parts per mil with respect to Lake Michigan water or 25 parts per mil, to ocean water (*26*). The assumptions in this calculation are: (1) the irreversibility of the photochemically produced exchange of isotopes and (2) the temperature at which equilibrium between the CO_2 and H_2O is established.

Despite this success in accounting for the O^{18} content of the atmosphere by assuming a stratospheric irreversible exchange of O^{18} between O_2 and CO_2, there is still the problem of demonstrating a transfer of the O^{18} enhanced oxygen from the stratosphere to the troposphere. As Dobson, Brewer, and Cwilong have pointed out (*4*), a "general world circulation between the equator and the poles which causes the air in the stratosphere to rise slowly near the equator and to subside slowly near the poles" has been postulated to explain differences in temperature in the stratosphere at low and high altitudes. These authors find it unnecessary to invoke this hypothesis, preferring to base the temperature differences on the differences in radiation due to different ozone content. Thus there seems to be no proof at the present time of vertical mixing between the low and high levels of the atmosphere, although horizontal winds of high velocity

are known to exist in the stratosphere. It would be extremely interesting to investigate the isotopic composition of oxygen in the stratosphere as well as from various geographical locations such as the arctic and the tropics. It might be possible to follow large-scale air currents in this way because, from all we know now, the photosynthesis reaction of the oceans is delivering to the atmosphere oxygen having a different isotopic composition from that already present. Similarly, the stratospheric oxygen may have an isotopic composition different from the oxygen in contact with the tropical oceans. The maximum expected difference between stratospheric and photosynthetic oxygen is 33 parts per mil of which the error of measurement is estimated as 1 part per mil.

We come finally to the thought that if oxygen exchange in the stratosphere is significant, then synthesis of oxygen in the stratosphere may also be significant, and that the total abundance of free oxygen in the atmosphere may be slowly increasing. In other words, it would appear that oxygen has a future as well as a past and present history.

(The author wishes to express his appreciation to J. J. Kaplan for information regarding the physics of the upper atmosphere, to H. C. Urey for recent, unpublished data on oxygen isotope ratios, to the Alexander Dallas Bache Fund of the National Academy of Sciences and to the Penrose Fund of the American Philosophical Society for grants in aid of the oxygen isotope studies.)

(For references see column 2, p. 96.)

On the Origin of the Chemical Elements

D. ter Haar[1]
Department of Physics, Purdue University

IN RECENT YEARS MANY ATTEMPTS have been made to explain the observed abundance of the chemical elements and their isotopes. A survey of papers on this subject will be presented in a forthcoming paper (*4*). In this article, an attempt will be made to connect these theories with the general cosmogony developed by von Weizsäcker (*9*), not by offering a complete and quantitative theory, but rather by sketching a possible way of combining ideas expressed by other authors into a theory which may, perhaps, be more satisfactory than the existing ones.[2] The limitations of earlier theories are considered in the survey paper (*4*) mentioned earlier.

The idea is to eliminate one of von Weizsäcker's initial conditions, on the one hand, and to suggest possible initial steps for the theories of van Albada (*1*), Beskow and Treffenberg (*2*), and Mayer and Teller (*7*). In von Weizsäcker's cosmogony the universe is, at the beginning of the present epoch, filled with a turbulent gas. The origin of this gas and its turbulence is assumed to be a problem lying outside the scope of this cosmogony. Von Weizsäcker further assumes, however, that the composition of this gas is the same as the present composition of interstellar gas, or stellar material. It may be sufficient, however, to assume this gas to consist of hydrogen only, thus simplifying the initial conditions of von Weizsäcker's cosmogony. Expressed differently, the solution of the problem of the origin of the chemical elements, other than hydrogen, is thus brought into the present epoch. By the "present epoch," we shall understand the period often referred to as the age of the universe. Following present ideas about the age of the universe, we shall put it at between 10^9 and 10^{10} years (*3, 4, 8*).

As was shown by von Weizsäcker, in the gas filling the universe, concentrations of mass and finally gaseous bodies with masses of the order of stellar masses will be formed. Due to the conservation of angular momentum, these bodies will be rotating fast. In the beginning the energy of these stars will be provided by gravitational energy, and later the deuterium reaction ($H + H \rightarrow D$) will set in. When the densities and central temperatures have become greater, the von Weizsäcker-Bethe carbon-nitrogen cycle will start. (The necessary carbon nuclei will have been formed by nuclear reactions in the way, for instance, discussed by Bethe.) When all the hydrogen has been used, the star will collapse. The development described by Hoyle (*5*) will follow. Of particular interest are those stars which have not yet lost their

[1] The author would like to express his thanks to Drs. Mayer and Teller for a discussion of the subject matter of their paper (7) and an opportunity to see the manuscript prior to publication. The material was presented at the Solvay Congress in 1948 and, for publication, will be extended to include a short survey of the older theories. The author is also grateful to Dr. von Weizsäcker for the opportunity to read his paper (*10*) prior to publication.

[2] Some of the ideas presented in this paper are similar to ideas expressed by van Albada and Hoyle.

rotation when their hydrogen is used up. At the interior of these stars heavy nuclei will be formed in a thermodynamical equilibrium. The most reliable analysis of the composition of the interior of such a star can probably be found in Beskow and Treffenberg's paper (*2*). The breakup of the star probably will be rapid, as has been emphasized by van Albada (*1*) and Hoyle (*5*), and in this way the heavy nuclei will be distributed over space.

These heavy nuclei will not, however, be the nuclei found now. As was stressed by van Albada (*1*), the ratio of protons to neutrons will be much lower for these nuclei than for stable nuclei found in nature. Radioactive processes will reduce these nuclei to stable nuclei. Mayer and Teller (*7*) have shown that these radioactive processes will lead to isotopic abundances in qualitative agreement with those observed. In this way, the final result of the processes described here would be a universe filled with chemical elements with about the right isotopic abundances. The advantage of the present theory over that of Mayer and Teller is that we are able to account for the neutron-rich heavy nuclei in a natural way, while Mayer and Teller have to introduce their "polyneutron," the origin of which remains an open question. Also, the present theory has the advantage of considering the total amount of elements in the universe, instead of only single concentrations of matter with masses of the order of stellar masses, as was done by previous authors.

Up to now, the picture given in the present paper has been purely qualitative. Let us try to indicate how it can be changed into a more quantitative theory. It will be shown, especially, that there is no reason as yet not to accept this solution, since it gives satisfactorily the ratio between the abundances of hydrogen and heavy elements. Expressed differently, the processes indicated here are probably sufficiently frequent to account for the present distribution of elements.

It is still impossible to use hydrodynamical arguments to predict the distribution function, $f(M)$, of stars over the various masses. It is possible, however, to use for this function the observational data of Kuiper (*6*). On the other hand, it is well known that stars with masses larger than the sun, which belong to an earlier spectral class, cannot have lived during the whole of the present epoch. Thus, whereas dG-stars, which are observed now, can have been formed at any moment during the last 10^{10} years, B-stars must have been formed in the last 10^8 to 10^9 years (*8*). B-stars which were formed earlier have long ago burned their energy and exploded. These stars (O, B, perhaps A) must, therefore, have been responsible for the presence of heavy elements. According to Kuiper's figures, these stars are, at most, 1 per cent of the total numb of stars. However, due to their large masses, th may possess as much as 5 per cent of the total ma of the stars.

If we wish to estimate how large a percentage of t mass of the universe has been involved in the proces leading to the formation of heavy elements, we have take into account three factors: (a) the present pe centage of early-type stars is artificially lowered b their short life; (b) only part of these stars will gi birth to heavy elements; the explosion may occur b fore the central density is sufficiently high; and (c about one half of the mass of the universe is no stellar, but interstellar material. Taking these factor into account we might safely conclude that at least per cent of the total mass of the universe must hav undergone the processes described above.

If we now compare the abundances found by Besko and Treffenberg (*2*) with the observed abundances, is seen immediately that with 1 per cent of the mas of the universe giving rise to heavy elements, the for mation of heavy elements has been sufficiently fr quent to explain their abundances. The high abun dance of helium can possibly be explained either b the α-radioactivity of the very heavy elements or b an evaporation from "normal" stars, where helium i continuously formed. The fact that the observe abundances of light elements (C, N, O) are so muc higher than in Beskow and Treffenberg's theory ma well be due to the possibility that many stars ma have been broken up before the formation of heav elements started (cf. Hoyle, *5*, and van Albada, *1*).

If a quantitative law for the distribution functio $f(M)$ and also for the relation between angular mo mentum and mass of a star was known, it would b possible to calculate more quantitatively both how large a fraction of the mass of the universe had bee involved in the various processes and how large a fraction of the O-, B-, and A-stars were broken up before attaining high central densities. It is satisfactory that preliminary considerations by von Weizsäcker (*10*) show that the observed correlation be tween spectral type and rotation, which points to a possible early rotational instability of O-, B-, and A-stars, can be understood, at least qualitatively.

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TECHNICAL PAPERS

The Influence of Thyroid and Thiouracil on Mice Exposed to Roentgen Radiation

Henry C. Blount, Jr. and Willie W. Smith

Laboratory of Physical Biology,
National Institutes of Health,
Bethesda, Maryland

Although reports are not entirely in agreement, there is considerable evidence that heat sensitizes neoplastic tissue to high-energy electromagnetic irradiation (*1, 3, 6*). It has been postulated that temperature effects are, at least in part, referable to effects on cellular metabolism, but few studies have been reported in which metabolic rate was varied independently. The present experiments were made to determine whether or not thyroid or thiouracil feeding would alter the incidence of death among mice exposed to severely damaging whole body radiation.

Mice were of the N.I.H. strain, the first shipment consisting of 70 males about 10 weeks old, the second of 59 males and 61 females about 6 weeks old. They were divided into 3 comparable treatment groups as shown in Table 1. One group was maintained on the stock diet of powdered Purina dog chow. Desiccated thyroid was added to the stock diet for the older mice in the second group, beginning 13 days prior to irradiation (0.5% for 9 days and 0.3% thereafter), and to that of the younger mice, beginning 8 days prior to irradiation (0.5% for 5 days and 0.3% thereafter). In the third group the older mice received 0.5% thiouracil with the stock diet, beginning 13 days prior to irradiation; the younger mice, 0.5% thiouracil beginning 8 days prior to irradiation.

Irradiation was administered at the National Cancer Institute. Peak voltage of the machine was 186 kv; effective voltage, 170 kv; current, 20 ma; added filtration, 0.55 mm of aluminum and 0.25 mm of copper; and focal distance 50 cm. Eight or 9 mice, drawn at random in approximately equal numbers from the three diet groups, were irradiated simultaneously. The mice were under observation for 4 weeks following irradiation.

Evidence that the thyroid of the diet strongly affected metabolic rate is adduced from the fact that when 8 mice from each diet group of the first shipment were subjected to a 24-hour fast in preparation for the determination of oxygen consumption, 4 of those on 0.5% thyroid died, while none of those on the control diet or on thiouracil died. As a result of this experience, we reduced the thyroid content of the diet to 0.3%.

A few determinations of oxygen consumption were made after the mice had been on the experimental diets for about a week and before they were irradiated. The method described by Tabor and Rosenthal (*4*) was used, except that each determination was made with 2 or 4 mice in the chamber, and the lowest value of 2 to 6 determinations of 5-min duration at 22° C was used for each group. The average for 8 mice receiving thyroid was 40% higher than that for mice on the control diet, while the average for 6 mice on thiouracil was 6% higher than the control value. A more extensive study of the oxygen consumption of thyroid-fed mice before and after irradiation is in progress.

The incidence of death following irradiation is shown in Table 1. The difference between the 54.8 mortality of the thyroid group and the 15.6% mortality of the control group is highly significant as shown by chi-square. The difference between the 9.4% mortality of the thiouracil group and the mortality of the control group is not statistically significant.

TABLE 1

THE INFLUENCE OF THYROID AND THIOURACIL ON THE INCIDENCE OF DEATH

Shipment no.	Desiccated thyroid		Control diet		Thiouracil	
	Dead	Alive	Dead	Alive	Dead	Alive
1 (♂)	13	8	5	19	4	21
2 (♂)	12	9	3	16	2	17
2 (♀)	9	11	2	19	0	20
%	54.8		15.6		9.4	

It is of additional significance that 20 of the mice receiving thyroid had died by the 10th day following irradiation, while at that time only 3 of those on the control diet had died. Among the younger mice (shipment 2), 6 died between the 3rd and 5th days, while the first death among those on the control diet occurred on the 5th day, and no others on the control diet died until the 10th day. All of the deaths in the thiouracil group occurred after the 10th day following irradiation.

By use of an oral clinical thermometer with the bulb completely inserted into the rectum, temperatures were determined on 6 mice of each diet group at the end of the 4 weeks of observation following irradiation. Temperatures of the thyroid group averaged 38.5° C (range, 38.2°–39.1°), of the control group, 37.6° (range, 37.4°–37.8°), and of the thiouracil group, 37.2° (range 37.0°–37.6°).

Thyroid feeding resulted in a relatively small increase in rectal temperature, while, without doubt, the metabolic rate was considerably elevated. In preliminary experiments the mortality of irradiated mice, kept in an environment of 10° C, was significantly higher than that of mice at 29° C. At 10°C the rectal temperature is reduced by only about 1 degree from its value in an environment

of 29° (*5*), while according to Herrington (*2*), total heat production is approximately doubled at the lower temperature.

It seems probable that metabolic activity, rather than body temperature, is the predominant factor in increasing the mortality of mice exposed to severely damaging Roentgen radiation. Further experiments concerned with these relationships are in progress.

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A Method for Studying Growth in Different Groups of Arthropods

Curtis L. Newcombe

Cranbrook Institute of Science, Bloomfield Hills, Michigan

Linear growth in arthropods is largely discontinuous and usually, but not always, most conspicuous during the molting interval (*1*, *5*). Shafer (*9*) likens the linear-growth curve to a series of steps. Size increments during the successive molts are subject to pronounced variation depending, in many instances, on the food supply and on the temperature factor. Also, the final size attained following a particular molt is a function of the initial size, *i.e.* the dimensions prior to molting. Hence, the effect of variation in respect to a particular molt is likely to be cumulative to different degrees in succeeding molts. Wesenberg-Lund (*10*) refers to the rearing method and the method of population analysis for studying age and size of insects at particular instars. MacKay and Weymouth (*4*) in their classical study of *Cancer magister* Dana used population data, largely, for their estimates of per cent increase in size, number of instars, age at sexual maturity, and maximum age.

Animals that grow by molting comprise such a large group that no one method is likely to apply reasonably well to all of them. Rather it is expected that a combination of two or more methods may be needed in the study of even one restricted systematic group. From our studies of the blue crab, *Callinectes sapidus* Rathbun, a method has evolved for estimating the number of postlarval molts typical of a species, and also the size characteristics of the different instars (*2*, *3*, *6*, and *7*). Because of the application of this procedure to other arthropod groups and its potential value as a tool in attacking diverse practical, as well as theoretical, growth problems, the essentials of the method are related here. The technic was made possible by the large numbers of crab measurements made by Miss Ellen H. Gray and the ingenious rearing experiments carried out by Mrs. Mildred D. Sandoz while working with the writer at the Chesapeake Biological Laboratory and the Virginia Fisheries Laboratory.

The immediate antecedent of these observations was the work of Robertson (*8*) who, by great patience and effort, was able to rear postlarval crabs of this species to an advanced stage in development. Cognizance of the difficulties involved and the obvious variability in the results discouraged similar attempts by us to solve the problem of rearing blue crabs through to the last instar.

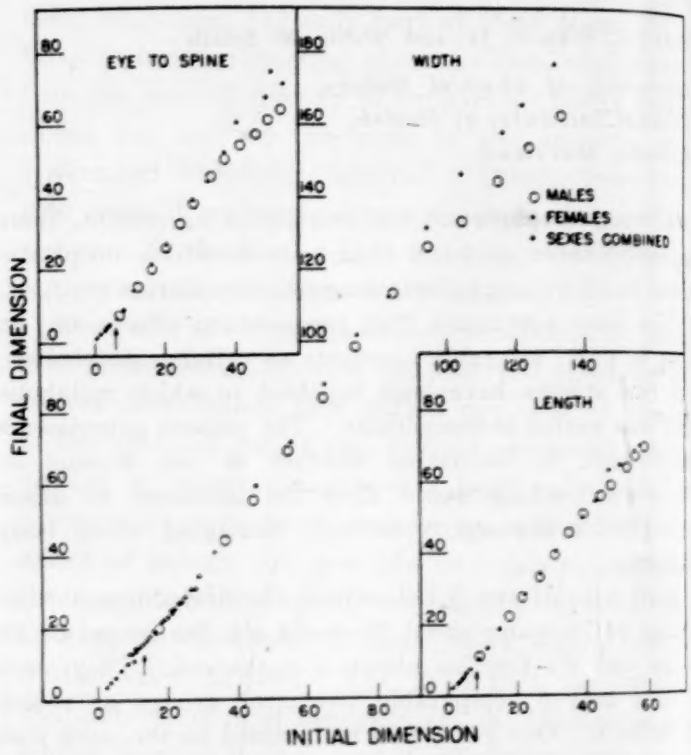

Fig. 1. Relation of initial to final size in *Callinectes sapidus* Rathbun. Sexes are combined in groups to the left of the arrows and in the plus groups.

Even if it were possible to do so, individual variation is so great that a prohibitive, and doubtless impossible, number of crabs would need to be reared in order to yield reliable size averages, representative of the species. The procedure outlined below proved to be reasonably satisfactory and is, seemingly, subject to wide application in the arthropod group.

Small crabs caught just prior to molting were kept in running salt water in the laboratory until they molted. Large crabs molted successfully in specially constructed floats kept near the shore. Hence, simulation of essentially normal conditions was accomplished. Reasonably large numbers of crabs of all sizes were measured before (initial dimension) and after (final dimension) molting. From these data a curve was constructed indicating, for example, the final width, corresponding to any initial width (Fig. 1). This growth curve proved to be a very valuable tool, because once the width of the first instar is known, we have a starting point for using the curve to estimate the theoretical number of instars characteristic of the species. Mrs. Sandoz established the mean width of the first postlarval instar to be 2.5 mm. Thus, from the chart we learn that a crab having an initial width of 2.5 mm has a final width of 3.7 after molting. But this final dimension now becomes the initial width

of the second instar which, according to the curve, reaches a final width, on molting, of 5.1 mm and it, in turn, again becomes a new initial width. Continuing in this manner, it has been possible to estimate the number of postlarval molts and the width of each instar, of which

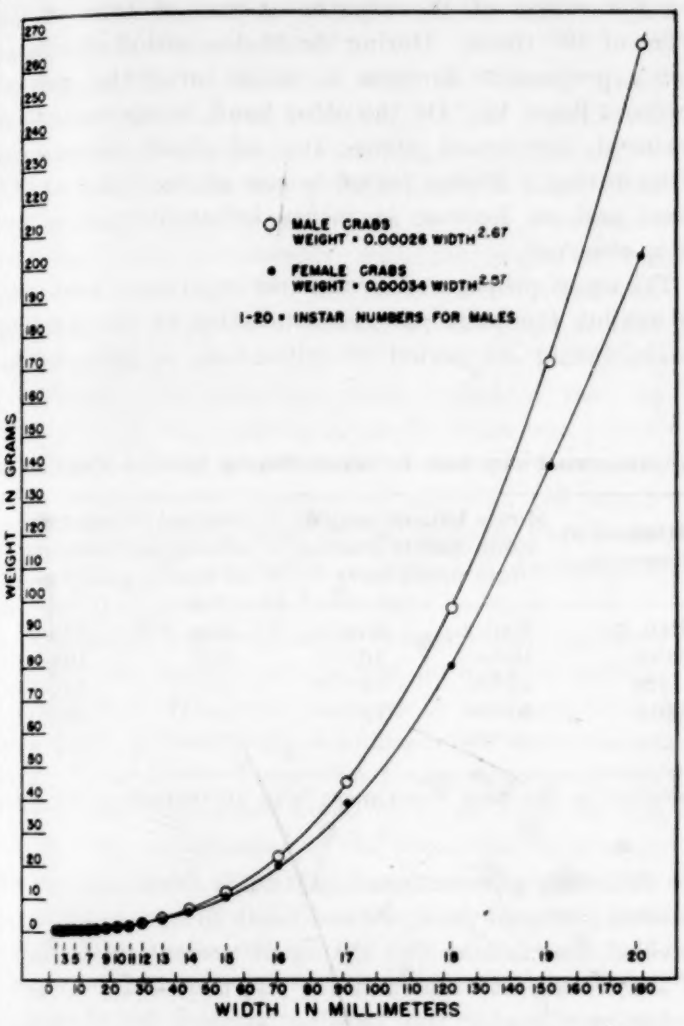

FIG. 2. Showing growth trends in *Callinectes sapidus* Rathbun, based upon growth curve of Fig. 1.

there are believed to be 19 or 20 in males and 18, or possibly 19, in female blue crabs (7). A mathematical equation was fitted to the molting curve for males and females so that from any initial width one can calculate directly the final width after molting. Hence, knowing the width of the first postlarval instar, it was possible to calculate the widths of the remaining instars.

To complete the story, it was necessary to establish the relationship between the width dimension, selected for a basic index of size, and other linear and also weight measurements. The allometry equation $Y = aX^b$, was found to constitute a satisfactory expression of the different linear and also weight relationships. Consequently, from a width measurement, any of the corresponding linear and weight dimensions can be readily ascertained. Since the width of each instar has been determined, it is now possible to calculate the remaining linear dimensions and the weights of each instar (Fig. 2).

The information provided by this procedure makes it possible to analyze certain characteristics of the growth of body parts in relation to one another and to the whole body. Also, a basis is provided for interpreting the effect of environmental conditions and mechanical injury on the normal growth curve as established by the preceding technics. The method has potential use for comparing differential growth rates in geographic varieties as well as closely related species.

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Cultivation of the Lansing Strain of Poliomyelitis Virus in Cultures of Various Human Embryonic Tissues[1]

John F. Enders, Thomas H. Weller,[2] and Frederick C. Robbins[3]

Research Division of Infectious Diseases, Children's Hospital,* and *Departments of Bacteriology, Comparative Pathology,* and *Pediatrics, Harvard Medical School, Boston

An extraneural site for the multiplication of the virus of poliomyelitis has been considered by a number of investigators (*2, 5*). The evidence that this may occur is almost entirely indirect, although recent data indicate that Theiler's mouse encephalomyelitis virus as well as various mouse pathogenic poliomyelitis-like viruses of uncertain origin may multiply in nonnervous tissue (*1, 3*). Direct attempts by Sabin and Olitsky (*4*) to demonstrate *in vitro* multiplication of a monkey-adapted strain of poliomyelitis virus (MV strain) in cultures composed of certain nonnervous tissues failed. They obtained, however, an increase in the agent in fragments of human embryonic brain.

The general recognition that the virus may be present in the intestinal tract of patients with poliomyelitis and of persons in contact with them emphasizes the desirability of further investigation of the possibility of extraneural multiplication. Accordingly, experiments with tissue cultures were undertaken to determine whether the Lansing strain of poliomyelitis virus could be propagated

[1] Aided by a grant from the National Foundation for Infantile Paralysis, Inc.

[2] Post doctorate Fellow of the U. S. Public Health Service.

[3] Senior Fellow in Virus Diseases of the National Research Council.

in three types of human embryonic tissues. The results are summarized here in a preliminary manner.

The technique was essentially the same as that recently described for the cultivation of mumps virus (*6*). The cultures consisted of tissue fragments suspended in 3 cc of a mixture of balanced salt solution (3 parts) and ox serum ultrafiltrate (1 part). Tissues from embryos of 2½ to 4½ months as well as from a premature infant of 7 months' gestation were used. These were: the tissues of the arms and legs (without the large bones), the intestine, and the brain. Each set of cultures included 4 or more inoculated with virus, and usually a similar number of uninoculated controls. The primary inoculum consisted of 0.1 cc of a suspension of mouse brain infected with the Lansing strain of poliomyelitis virus.[4] The identity of the virus was verified by (a) the character of the disease it produced in white mice following intracerebral inoculation; and (b) its neutralization by specific antiserum.[5] Subcultures were inoculated with 0.1 cc of pooled *centrifuged* supernatant fluids removed from the previous set of cultures.

The procedure of cultivation differed from that usually followed by other workers in that the nutrient fluid was removed as completely as possible and replaced at periods ranging from 4 to 7 days. Subcultures to fresh tissue were prepared at relatively infrequent intervals, ranging from 8 to 20 days.

Two experiments have been carried out employing cultures composed chiefly of skin, muscle and connective tissue from the arms and legs. The findings in each have been essentially the same. In the first, a series of cultures has now been maintained for 67 days. During this interval, in addition to the original set, three successive subcultures have been made to fresh tissue and the fluids have been removed and replaced 10 times (Table 1). Assuming that at each change of fluid a dilution of approximately 1:15 was effected and that at the initiation of each set of cultures the inoculum was diluted 30 times, it has been calculated that the 10% suspension of infected mouse brain used as the primary inoculum had been diluted approximately 10^{17} times in the fluids removed from the third subculture on the 16th day of cultivation. These fluids, however, on inoculation into mice and monkeys, produced typical paralysis. Accordingly, since the mouse LD_{50} of the original inoculum was 10^{-2}, it would appear that the increase in virus during the course of the experiment was at least of the order of 10^{15} times. During the 67-day period of cultivation a progressive decrease in mouse infectivity was recorded (Table 1). On the other hand, in the second experiment, mentioned above, the calculated increase in virus during a 52-day period is now of the order of 10^{38} times and no decrease in mouse infectivity has so far been observed.

The agent propagated in the first experiment continued to exhibit the principal characteristics of the Lansing strain during the period of cultivation, as indicated by the following observations: (a) fluids from each set of cultures produced paralysis and death in mice after intracerebral inoculation; (b) the agent present in the fluids of the second set of subcultures was neutralized by antiserum specific for the Lansing strain; (c) following intracerebral inoculation, the fluids from the third set of subcultures produced flaccid paralysis within 7 and 10 days, respectively, in two rhesus monkeys. Microscopic examination of the spinal cords of these animals revealed lesions characteristic of poliomyelitis.

Cultures of intestinal tissue were prepared with fragments from the entire intestine of human embryos, except in one experiment in which jejunum of a premature infant was used. In the latter, the bacteria were eliminated in the majority of cultures by thorough washing of the tissue and by the inclusion in the original nutrient fluid of 100 units/cc of penicillin and of streptomycin.

In one experiment with embryonic intestine, which included two subcultures and 7 changes of nutrient fluid, the calculated dilution of the original inoculum was of the order of $10^{12.7}$ times. On the basis of the mouse LD_{50} of the original inoculum and that of the last supernatant fluid, it was calculated that the virus had increased about $10^{12.7}$ times. The identity of the agent thus cultivated in intestinal tissue has not yet been confirmed by neutralization tests or monkey inoculation, but it elicits a response in the mouse typical of the Lansing virus.

The cultures prepared with intestine of the premature infant have, so far, been maintained 17 days with 3

TABLE 1

MULTIPLICATION OF LANSING POLIOMYELITIS VIRUS IN TISSUES OBTAINED FROM THE EXTREMITIES OF HUMAN EMBRYOS

Culture set	No. of nutrient fluid changes prior to subculture		Day of incubation subculture done		Mouse LD_{50} of pooled fluids used to inoculate subcultures		Calculated dilution of original inoculum at time of subculture	
	Exp. 1	Exp. 2	Exp. 1	Exp. 2	Exp. 1	Exp. 2	Exp. 1	Exp. 2
Original*	3	4	20th	20th	$10^{-2.0}$	$10^{-1.57}$	10^{-5}	$10^{-6.2}$
1st subculture	2	2	19th	12th	$10^{-1.57}$	$10^{-1.71}$	$10^{-8.8}$	$10^{-10.0}$
2nd subculture	2	4	12th	20th	$10^{-0.63}$	$10^{-1.34}$	$10^{-12.6}$	$10^{-16.2}$
3rd subculture	3	..	16th	....	$10^{-0.16}$	.....	$10^{-17.7}$	.....

* The LD_{50} of the suspension of mouse brain used as the inoculum in the first experiment was 10^{-2}; that of the suspension employed in the second experiment was $10^{-1.01}$.

[4] This strain was isolated by Dr. Charles Armstrong and obtained through the courtesy of Dr. S. D. Kramer.

[5] This serum was obtained through the courtesy of Dr. Isabel Morgan. It was prepared by hyperimmunization of rhesus monkeys with her strain of the Lansing virus.

anges of nutrient fluid. Virus has been demonstrated, mouse inoculation, in the fluids removed during the urse of the experiment, including that of the 17th day. e calculated multiplication of the virus was approxiately 10^3 times. This finding suggests that multiplicaon occurred in this tissue which, from the embryologic int of view, is more mature.

To compare the increase of virus in nervous tissue th that in tissue of the intestine and the extremities, ltures of embryonic brain were prepared. The multiication of the virus in this medium has been comparable that in the other types. Thus in one experiment rried out contemporaneously with the series of emyonic intestinal cultures mentioned above, the calated multiplication of virus was of the order of 10^{12} nes.

No evidence was obtained which indicated that an ent other than the Lansing strain of virus was propated in any of the three types of tissue. Mouse inetivity tests for the presence of virus in the supertant fluids of uninoculated control cultures were negave. Aerobic and anaerobic cultures of supernatant ids yielded no growth of bacteria.

On microscopic examination of fragments of the three pes of tissue, removed after about 30 days of cultivaon, differences have been observed in cell morphology tween those derived from inoculated and uninoculated ltures. Many of the fragments from uninoculated culres contained cells which appeared to be viable at the e of fixation, as indicated by the normal staining propties of the nuclei and cytoplasm. In contrast, the clei of the majority of the cells in fragments from oculated cultures showed marked loss of staining propties. Since the amount of material which has been died is as yet relatively small, one cannot conclude t the changes observed in the inoculated cultures were used by the virus.[6]

It would seem, from the experiments described above, t the multiplication of the Lansing strain of polioelitis virus in the tissues derived from arm or leg, ce these do not contain intact neurons, has occurred her in peripheral nerve processes or in cells not of rvous origin.

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Insect Vectors of Phony Peach Disease[1]

William F. Turner

United States Department of Agriculture,
Agricultural Research Administration,
Bureau of Entomology and Plant Quarantine

Phony peach is a virus disease of economic importance in the southeastern United States (*1*). While the disease attacks other species of the genus *Prunus*, its most serious effects result from heavy infections in commercial peach orchards, particularly in the South Atlantic and Gulf Coast States from South Carolina to Louisiana. The disease has caused the loss of more than 1,500,000 peach trees during the period from 1929 to 1947, inclusive.

Since 1936 the Bureau of Entomology and Plant Quarantine, in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering, has been conducting research in an effort to find the insect vector, or vectors, of phony peach. Following an extensive survey of insects associated with peach orchards in areas where the annual disease incidence was high, in other areas where few new cases occurred each year, and finally, in areas where there appeared to be no local spread, a test program utilizing the most likely insect suspects was undertaken.

Results of the survey, together with data derived from experimental transmission of the disease, suggested the probability that phony peach was being spread by one or more stem-feeding Cicadellidae (leaf hoppers) belonging to the subfamily Tettigellinae. Although 53 species of insects, including members of several different families of Homoptera and a number of species of Cydnidae (Hemiptera), have been used in transmission tests, most attention for the last four years was given to four species of leaf hoppers.

From 1939 through 1944 the work was conducted at Chattanooga with field-grown peach trees that were unprotected from possible natural infection. During the course of these tests three of the experimental trees developed symptoms of the disease. One had been subjected to inoculation by *Cuerna costalis* (F.), one by *Graphocephala versuta* (Say), and one by *Homalodisca triquetra* (F.),[2] all members of our selected group of suspects. One case of phony peach occurred in one of the many check trees that were maintained.

In 1945 the work was transferred to Fort Valley, Georgia, where it was necessary to grow the experimental trees in a large screened cage because of the certainty of considerable natural spread in unprotected trees. Insects

[1] The diagnoses on which this report is based were made by Lee M. Hutchins and L. C. Cochran, of the Bureau of Plant Industry, Soils, and Agricultural Engineering, and by L. D. Christenson and William F. Turner, Bureau of Entomology and Plant Quarantine, of the United States Department of Agriculture.

[2] The leaf hoppers actually used in each of these and all other tests were identified by P. W. Oman and J. S. Caldwell, Division of Insect Identification, Bureau of Entomology and Plant Quarantine.

collected on peach trees, weeds, and wild and cultivated shrubs were confined in cheesecloth bags on branches of phony trees. After 4 or 5 days the bags with their contained insects were transferred to test trees growing in the large cage. The bags were left on these test trees for 30 or more days, unless all the insects had died earlier. At the end of the test period the bags were carefully removed in such a manner that none of the insects escaped within the large screened cage. The test trees were Elberta June-buds in their second year from seed. In order to provide fully adequate controls, alternate trees were left as checks. Transmission tests were made from April to October. During the following winter the test trees and checks in the cage were dug and replanted in isolated plots in areas where there were no commercial orchards and where phony disease was rare or unknown.

Phony disease has a long incubation period in peach trees, apparently from about 18 months (or two growing seasons) to as much as 3 years. Although a few of the trees used in the 1945 tests showed suspicious symptoms in September 1947, it was not until the spring of 1948 that reliable diagnoses could be made. At that time 7 trees were positively phony, and 8 more were almost certainly so. Of the 7 positive cases, two had been inoculated by *G. versuta*, three by *H. triquetra*, and two by *Oncometopia undata* (F.). All of the 8 trees that were almost certainly diseased had been inoculated with *H. triquetra*. None of the check trees showed any symptoms of the disease.

TABLE 1

Species	Total No.	Phony peach transmissions	
		Definite	Probable
H. triquetra	203	8	8
C. costalis	64	1	2
O. undata	26	3	0
G. versuta	20	2	0

In contrast with the 1945 series, a number of the trees used in the 1946 experiments showed positive symptoms in July 1948. At that time seven definite cases of phony peach were noted. One of these trees had been inoculated by *C. costalis*, one by *O. undata*, and five by *H. triquetra*. At least two other trees inoculated by *C. costalis* are almost certainly diseased. All check trees appeared to be normal.

The totals for definite and probable insect transmissions of phony peach obtained in the test series of 1945 and 1946 are presented in Table 1. One check tree was provided for each test tree, a total of 313 in all. All check trees are still normal.

The definitely positive results represent from 2 to 28% successful transmission by the different species. Although all these insects are general feeders, three species are known to be associated with peach trees at certain seasons. For the fourth one, *C. costalis*, a natural association is doubtful, but the insect survives for periods of a month or more when confined on peach. This species has thus far been the least successful of the four in transmitting the disease. All four species belong to the subfamily Tettigellinae, and it appears quite possible that other members of this group may be able to transmit phony peach even though they may be of no real importance as vectors.

In 455 experiments involving the use of the remaining 49 species of insects that were tested, all results were definitely negative.

Reference

1. HUTCHINS, LEE M. *Ga. State entomol. Bull.* 78, 1933.

Inhibition of the Adenosinetriphosphatase Activity of Preparations of Myosin[1]

Francis Binkley

Laboratory for the Study of Hereditary and Metabolic Disorders* and *Department of Pathology and Medicine, University of Utah School of Medicine

During the past year we have been investigating the inhibition of the adenosinetriphosphatase activity of the myosin complex by extracts of the posterior pituitary

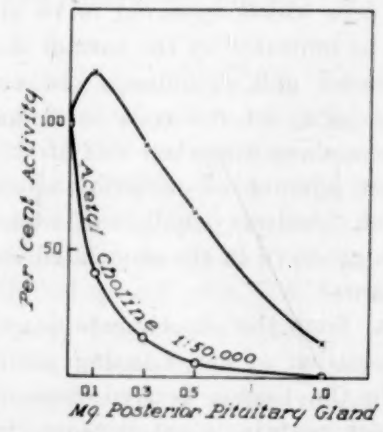

FIG. 1. ATPase activity in the presence of extract of posterior pituitary gland and acetylcholine. The percentages of the control values are plotted. Activity was determined by analysis for inorganic phosphate after 5-min incubation at 30° C in 1 M KCl buffered at pH 9.0 with 0.1 M $NaHCO_3 - Na_2CO_3$. One mg of $CaCl_2$, 10 mg of ATP (sodium salt), and a solution of twice-precipitated myosin (0.2 mg of protein nitrogen) containing 0.001 M NaCN were present in a total volume of 5 ml. Acetylcholine and the soluble material of the desiccated posterior pituitary gland were added as indicated. The incubation was terminated by the addition of trichloroacetic acid to make a final concentration of 5%.

gland. Our interest in this casual observation was due to the finding that the inhibition was greatly reinforced by the addition of acetylcholine. Although a considerable mass of data has been accumulated, truly definitive experiments have not been devised, and it is considered

[1] These studies were supported by a grant from the U. S. Public Health Service.

desirable not to delay further the presentation of our results.

Results, typical of those we have obtained, are illustrated in Figs. 1 and 2. Twice-precipitated myosin from the rat, obtained by a procedure utilizing cyanide (*1*), was used in these experiments. Two methods were necessary in following the ATPase activity. For comparative studies, analysis for inorganic phosphate was sufficient, but, in order to follow rapid changes, manometric methods (*2*) were necessary. It is apparent from Fig. 1 that an extract of the posterior pituitary gland[2] is inhibitory at most concentrations but is capable of activation when

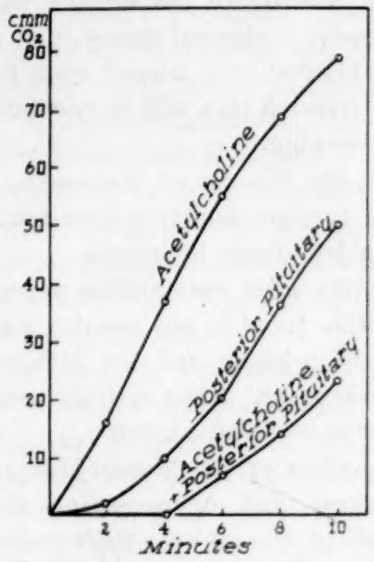

FIG. 2. Manometric measurement of inhibition of ATPase activity of myosin. The incubations were conducted in an atmosphere of nitrogen-carbon dioxide in 1 M KCl buffered with 0.1 M carbonate-bicarbonate. The initial pH (after saturation) was about 8.2; the total volume was 3.5 ml and only half the amount of myosin was used, but, otherwise, the substrates were the same as in Fig. 1. The soluble material from 1 mg of desiccated posterior pituitary gland and acetylcholine in a final concentration of 1:30,000 were used as indicated. After 30 min, the CO_2 production was equal in all cases, and the amounts of inorganic phosphate in the digests were identical within the range of error of the methods.

used in lower concentrations. If acetylcholine is supplied, the extract of posterior pituitary gland is inhibitory at all significant concentrations; acetylcholine was without effect when added without the extract of the posterior pituitary gland. It is possible that the inhibition with the crude extract of the posterior pituitary gland was due to a significant concentration of acetylcholine in the extracts of the gland. A factor not covered in Fig. 1 concerns the concentration of calcium; maximal inhibition was obtained with maximal activation of the enzyme by calcium ions. When the calcium level was low, little activity was observable, and the inhibition was difficult to demonstrate; when calcium was supplied in great excess, the inhibition was greatly reduced. For example, with 1 mg of $CaCl_2$, only 22% of the control activity (at 5 min) was observed, whereas the comparative value with 5 mg was 51%. In Fig. 2, typical data obtained by manometric methods are represented. It is seen that after a few minutes the inhibition disappeared; after this stage the ATPase activity proceeded at a normal velocity and to the same extent as the control. In studies of this release of inhibition it was found that the release is delayed by anaerobic conditions or by addition of eserine or DFP. In so far as could be determined, the release of inhibition is due to hydrolysis of acetylcholine and/or enzymatic or oxidative destruction of the factor in the extract of the posterior pituitary gland; *i.e.* inhibition was re-established, after release, by the addition of either extra acetylcholine or extra extract of the posterior pituitary gland in the presence of an excess of the other material. It was not possible to predict, within narrow limits, the amount of extract of posterior pituitary gland necessary to establish complete inhibition with different preparations of myosin; concentrations of acetylcholine varying from 1:10,000 to 1:100,000 were not found to differ with various preparations of myosin except in so far as the release of inhibition was concerned. Release of inhibition was delayed longer with higher concentrations of acetylcholine. In no case did we fail to obtain inhibition of the activity of myosin from rabbit or rat with the combination of posterior pituitary and acetylcholine.

It was found impossible to obtain adequate purified preparations of the known factors of the posterior pituitary gland for comparison, but certain observations have indicated a possible identity of our factor with one or more of the known principles of the posterior pituitary gland. The active material was found to dialyze through Cellophane membranes and to be inactivated by oxidation with bromine water, by treatment with 1 N NaOH for 3 hrs at room temperature, and by hydrolysis for 3 hrs at 94° with 1 N HCl. Activity was also destroyed by incubation of the extract of posterior pituitary gland with an extract of duodenum of the hog. Commercial preparations of "Pitressin" were more active than those of "Pitocin." Nervous tissue (brain of rats) was found to contain similar material, although in an apparently lower concentration than the posterior pituitary gland.

The significance of these results is difficult to assess at this time. If a relaxation mechanism for the transfer of energy to the myosin complex is assumed, the results would be grossly consistent with the known effects of acetylcholine ,and of the principles of the posterior pituitary gland. Studies of the physical aspects of this phenomenon have been seriously handicapped by the time factors involved, and our results do not allow for a unique interpretation as to whether or not the myosin complex is in the contracted state during the period of inhibition.

[2] Prepared from desiccated posterior pituitary glands supplied through the courtesy of Dr. Oliver Kamm, of Parke, Davis and Company. One hundred mg of the dried powder was extracted with 10 ml of saline, and the filtrate was used in the experiments reported here. The sodium salt of ATP was obtained through the courtesy of Dr. E. A. Osterberg, of Abbott Laboratories.

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Comments and Communications

In Support of Michurin's Biological Theory in Higher Institutions of Learning

[The following editorial, by S. Kaftanov, Minister of Higher Education in the USSR, is published in its entirety from *Izvestia*, September 8, 1948, in the belief that it has high informational value for scientists in America.]

There are two opposite trends in biological science. One of them is progressive, and materialistic, called Michurin's theory in honor of its founder, the great reformer of nature, Ivan Vladimirovich Michurin; the other is the reactionary, idealistic Weismann's or Mendel-Morgan theory. The founders of this theory were, as it is well known, reactionaries in science: Weismann, Mendel, and Morgan.

In opposition to the Mendel-Morgan trend, Russia developed and, encouraged by the Soviet regime, brought to its full bloom, the great theory of the great modifier of nature I. V. Michurin.

Michurin's materialistic theory has been continually enriched by the works of his followers, with the academician T. D. Lysenko at their head. This trend in biology has developed into a mightly current which has taken hold of the masses. It inspires millions of collective farmers with faith in the creative power of their efforts and gives them a firm assurance in the realization of new successes in the field of abundancy of farming products.

The Michurinists have proved, not by word, but by demonstration, that it is possible to direct the inborn qualities of animals and plants and to influence the development of animals and plants in a desired manner. Michurin's theory has adopted and developed the best sides of Darwinism. Darwin had explained the evolution of animals and plants from the materialistic point of view. Michurin has developed this knowledge and taught methods of directing the process of producing new species of plants and new species of domestic animals, thus transforming Darwinism into a really practical, creative doctrine.

Michurin's theory is closely bound to another progressive trend in our science—that of Williams' methods of fertilizing the soil, methods that have adopted and developed the best ideas of the Russian classics in the science of agriculture, those of Dokuchaev, Kostichev, and others.

Thanks to the care of the Bolshevist Party and of the Soviet Government, as well as to the personal care of our great leaders, Lenin and Stalin, Michurin's theory has been preserved from oblivion and has become the property of the people. The efforts of Michurin's followers, led by the academician T. D. Lysenko, have brought it to a new height of achievement. During the last session of the USSR Lenin Academy of Agricultural Sciences, the report of academician T. D. Lysenko concerning the status of biological science, duly supported by the Central Committee of the All-Russian Communist Party, has been made subject of consideration. This session has become an important factor in the strengthening and further expansion of the progressive biological theory of Michurin. This session has brought to light the opponents of Michurin's doctrine in biology and has dealt a stunning blow to the reactionary Weismann-Morgan theories. This session has proved to be the greatest triumph of the victorious Michurin theory.

The task of the future is now to develop and to spread with the utmost persistence the world's most advanced and most progressive biological theory, that of Michurin. The success of this task will depend upon the system of teaching and of research that will be carried on in higher institutions of learning.

Unfortunately, the theories of Weismann, Mendel, and Morgan, born in foreign countries, have found their supporters in the midst of our biologists.

The first and the most outstanding representative of this pseudoscientific trend in our country was the Leningrad professor Filipchenko and the Moscow professors Koltsov and Serebrovsky. They actively professed racist pseudo science—the so-called eugenics.

The first supporters of the Mendel-Morgan theories—Filipchenko, Koltsov, and others—openly disavowed the materialistic basis of Darwinism; their modern followers and supporters have done their utmost to mask and hide their anti-Darwinistic idealistic opinions and have always carried the banner of Darwinism. Amidst these, the academician I. I. Schmalhausen has to be named first.

Academician Schmalhausen denies the inheritance of acquired characters. He finds that evolution depends upon mutations which originate directly in the germ cells of the organism and have a quite accidental and indeterminate character, not regulated by the conditions of its life. This idealistic, reactionary theory is fundamentally antagonistic to Darwin's teaching. Nevertheless, Schmalhausen always hid under the banner of Darwinism.

Weismann's reactionary theory has found many adherents and supporters in numerous biological research institutions, as well as in the Universities of Leningrad and Moscow and, especially, in the Timiriaseff Academy of Agriculture.

Our homemade Weismannists, such as Academician Schmalhausen, Professors Serebrovsky, Zavadovsky, Zhebrak, Dubinin, and others, have fought for years the progressive and revolutionary teaching of Michurin's biology.

The laxity of certain ministers and institutions, of the Minister of Higher Education in particular, has encouraged these people and has given them the opportunity of occupying many responsible positions in universities, institutes, etc. Using these opportunities they strongly opposed the Michurinists, hampered their work, sometimes treated them with contempt, and thus did the greatest harm to Soviet science and national agriculture.

It is in the Moscow and Leningrad Universities that the

bearers of this reactionary-idealistic Weismann's "science" had built their mightiest strongholds.

Thanks to the laxity of the president of Moscow University, as well as of that of the Central Administration of the Universities of the Ministry of Higher Education, efforts have been made in the Biological Faculty to organize the anti-Michurinists by means of conferences of anti-Darwinistic character with specially selected participants; the Michurin theory was there and then treated with the highest contempt.

Several chairs of the Biological Faculty of the Leningrad University were also occupied by representatives of formal genetics. Professor Poliansky, vice-president of the University, spoke openly against the Michurin doctrine and its followers. The former vice-president of the Biological Faculty, Docent Lobasheff, actively opposed the appointment of Michurinist biologists.

Many biological chairs at other universities were also occupied by anti-Michurinists—for instance, Professor Poliakov in Kharkov, Professor Gershenson in Kiev, Professor Chetverikov in Gorky. This proves that the Ministry of Higher Education, as well as its Central Administration of Universities, was inefficient in its supervision of biological studies in the universities.

The same is the case in agricultural colleges and even in the most important one, the Timiriaseff Academy of Agriculture—several leading biological chairs have been occupied, up to the present, by anti-Michurinists, for example, the anti-Michurinist Professor Zhebrak held the chair of genetics at the Academy. Many other chairs were also held by formal geneticists, as Professor Borisenko and others. Even the director of the Academy, Professor Nemchinoff, shared the convictions of Weismannists and opposed the appointments of Michurinists.

Nevertheless, it is noteworthy that many biological chairs in agricultural colleges are occupied by worthy representatives of the progressive Michurin theory, who worthily carry on the great work of the famous scientist Ivan V. Michurin. Such are: Professor Yakoleff of the Michurin Fruit and Vegetable Institute, Professor Paguibin of the Tashkent Agricultural Institute, Professor Tikhonoff of the Kazan Agricultural Institute.

In other branches of agrobiological science (agriculture, pedology, cultivation of fruits and vegetables) the majority of the chairs in agricultural colleges are occupied by representatives of the progressive Michurin theory.

Strong defects in the teaching of biology can be traced also in medical colleges. The teaching of biology is based in many of these colleges on textbooks permeated with Mendel-Morgan ideas. Many of the chairs of medical institutes are also occupied by supporters of Mendel and Morgan in biology or by persons who, although not actively opposing the Michurin doctrine, are, nevertheless, basing their convictions and pedagogical activities on the spirit of the Weismann-Mendel-Morgan ideas.

Considerable defects in the teaching of biology exist also in teachers' colleges. The Departments of Teachers' Colleges of the Ministry of Higher Education, and the Ministry of Public Education of the Federation of Republics, have not sufficiently opposed the anti-Michurin trend that tended to keep out the Michurinists.

The Ministries of Higher Education, of Agriculture, of Public Health, and of Public Education have not become aware soon enough of the reactionary character of the anti-Michurinist trend in biology, did not put a stop to the spreading of such reactionary ideas, and did not create a free field for the new generation of Michurin's followers. And there is no doubt that these followers are very numerous.

This has been proved by the session of the Academy of Agriculture when many of the members of the Colleges spoke fervently in favor of Michurin's theory.

We must admit that the principal responsibility for the defects of the teaching of biology lies on the Ministry of Higher Education.

We are first of all responsible for not having used enough propaganda for the development of Michurin's doctrine in biology, for having been blind to the dangerous activities of anti-Michurinists in our higher institutions of learning, and for having admitted them to leading roles in many of them. This is the principal cause of the great defects in our teaching of biology, which was in evidence up to the last session of the Lenin Academy of Agriculture.

The first task of the Ministry of Higher Education must now consist in the elimination of defects in the field of biology teaching and in the clearing of the field for Michurin's doctrine. Curricula and programs, textbooks, and methods of teaching and of research must be reexamined and reorganized as must the entire system of education and training of cadres of scientists and the activities of publishers and of journals. All biological chairs and faculties must be held and supported by qualified Michurinists, capable of developing the progressive Michurin's doctrine.

The success of this reform in the teaching of biology in our colleges will depend most of all upon the right choice of the teaching personnel.

Action along these lines has already been started. The anti-Michurinist Nemchinov, former director of the Timiriaseff Academy of Agriculture, has been replaced by Comrade Stoletov, and Academician Lysenko has taken charge of the chair of genetics and selection; Academician Present has replaced the anti-Michurinist Yudintseff as dean of the biological faculty of the State University of Moscow, etc. Our present aim is to fill the ranks of the teaching personnel by biologists-Michurinists.

Programs of basic courses must be urgently re-examined and modified. Many of these programs in the biological sciences are either entirely based on the Mendel-Morgan theories or considerably affected by the revelations of the reactionary biological "science." The reform of those programs should not be delayed even for a single day. This is one of the most urgent aims.

The textbooks of basic courses in biology are quite unsatisfactory. What has been published up to the present in biology for colleges does not guarantee an education based on the progressive Michurin doctrine.

Publishers specializing in biological literature (such as Selkhozgiz, Medgiz, "Soviet Science," the Academy of Science, Uchpedgiz, etc.) have not been aware of their responsibility when publishing theoretical or popular scientific books and other works on biology for colleges.

An illustration of this state of things is given by the publication of a book written by a member of the Academy of Medical Sciences, S. N. Davidenkov, entitled "Evolutionary-Genetic Problems in Neuropathology." It was published in 1947 with an enthusiastic preface by Academician L. Orbeli. Fully accepting the Mendel-Morgan "theories," the author made an attempt to revise the theory of Engels concerning the humanization of apes under the influence of their working activities.

We must have textbooks based on the progressive Michurin theory.

Schools for higher education will not be able to carry through this reform of teaching in biological sciences if they do not at the same time reconstruct their scientific research work.

Much of this research work, led by partisans of Mendelism-Morganism, had but slight relation to real life dealing with the practice of medicine, agriculture, veterinary science, and animal husbandry. Professor Schmalhausen, for example, holding the chair of Darwinism in the University of Moscow, published volumes of "works" dealing with problems that have nothing to do with the practice of Socialist Construction.

At the University of Kharkov, methods were applied to problems of Darwinism and genetics that had nothing to do with practical needs of life. Docentin Mikhailova occupied herself with "Interspecific Divergence and Crossability in the Genus *Dianthus*." Docent Dubovsky had for his objective the elucidation of "The Cytological Basis of the Early Stages of Divergence in Mosquitoes of Different Species and Subspecies." Countless other problems, without any theoretical or practical significance, were likewise pursued, serving sometimes only as evidence for pseudoscientific conceptions in biology.

Detachment from life, limitations of academic outlooks, practical sterility, such are the qualifications of the scientific work produced by all research carried on by supporters of Mendelism-Morganism. It is necessary to make a sharp change in all scientific research done by our colleges and direct it toward the most active collaboration with requirements of practical life, as well as with the interests of our national economy.

The party of Lenin-Stalin protects the progressive Soviet science against infiltration of foreign, reactionary influences. The history of our Bolshevist Party serves as an example of a continuous and strenuous fight for a flourishing, progressive science, a science "that has the courage to tear down old traditions, rules, forms, when they prove to be outlived, when they become breaks stopping the onward movement, a science that creates new traditions, new forms, new rules" (Stalin).

The struggle in the field of biology has ended in complete triumph of Michurin's doctrine, presenting new stage in the development of materialistic biology.

Thanks to the Bolshevist Party and, personally, to Comrade Stalin, ways for the further triumphant march of the most progressive Michurin biological science are now clear. The scientists of our colleges will apply, from now on, all their energy to the propaganda of Michurin biology and to the support of undivided rule of Michurin's biological doctrine in our higher institutions of learning.

Instruments for Recording Blood Pressure

In a recent issue of *Science* (October 8, p. 393), Dan F. Marsh points out that a photoelectric recording microammeter may be used in connection with a strain-gage manometer to record the mean blood pressure of small animals. The models mentioned are entirely satisfactory for the purpose described but are by no means the only instruments of the 8CE type which may be used with these manometers.

In addition to the photoelectric microammeters, a number of other recording instruments may be used with good results. Recording potentiometers and resistance thermometer recorders made for industrial use are quite suitable. These types have the proper speed of response to indicate mean pressures and to be insensitive to individual pulses.

Standard models of strain-gage manometers that have a linear frequency range up to 70 cycles/sec are available. Such manometers are adequate for the accurate recording of arterial pulse contours in humans and in larger experimental animals. When used with the Brush amplifier and pen motor it is possible to realize all the advantages of ease in operation of the manometer as well as the advantages of a direct-writing recorder. In addition, accurate measurements of the systolic and diastolic pressures are possible. It is also possible to use these manometers with the string-type electrocardiograph galvanometer.

J. P. Meehan and R. D. Meyer

Department of Physiology,
University of Southern California
School of Medicine

Requesting Reprints from Abroad

D. J. Bell, of the University of Cambridge, reports that he has received over 200 requests from U. S. scientists for reprints of one of his articles, of which he was allowed only 50 copies. Believing that many British scientists have been faced with a similar problem, he has asked *Science* to publish the brief reminder that paper is scarce in the United Kingdom and that, for economic reasons, many British scientists do not feel that they can afford to reply to such requests, much as they would like to do so.

In Memoriam

Robert G. Green
1895–1947

Robert Green was a naturalist-turned-doctor in the rest sense. Loving the out-of-doors and its crea-res, he gave his mind to their diseases. The unex-ined death of an owl or snowshoe rabbit was ough to start him on a long, purposeful investiga-n, during which he exploited nature's resources as ll as his own. By inoculating horned owls, barred ls, and screech owls, he showed that the dead bird been victim to an unknown virus; and by watch-" snowshoes" month after month in their forest main he discovered "shock disease," a malady so pleting the blood sugar that the animal, if abruptly ightened, dies at its first leap. When litters of wild xes, lately whelped, were needed for tests of the fox cephalitis he had discovered, he got the litters as a tter of course. It never entered his reckoning that y might be hard to come by.

There is much for the field naturalist in Green's pers, told because pertinent to his work—for ex-mple, his comparison of the habits of the ruffed ouse, snowshoe rabbit, and cottontail, as bearing on ir relative infestation with the rabbit ticks which nsmit tularemia, and his demonstration that the owshoe lives its entire life within a quarter-mile where it is born (a fact disclosed by the banding of ousands of rabbits as part of a study of the ryth-ical rise and fall in their numbers). Some of his ork had immediately practical aspects. An encepha-is was ravaging the silver fox ranches of the North-st when he revealed its virus cause and devised a ccine which stopped it. Appealed to again by the anch owners, because now another strange illness d appeared among their animals, he saw that the pastic paralysis which had developed was like Wer-cke's polioencephalitis in man and traced it to a ck of vitamin B_1, as in the human case. The foxes d been kept on frozen fish, and this, he found, con-ined an agent so potent as to destroy the entire itamin intake if the diet contained more than 10 er cent of it.

Green always had larger matters in mind. During e period of excited conjecture following crystalliza-n of the tobacco mosaic virus, he put the case for uses being retrograde organisms in a way which s not been bettered (*Science,* 1935, **82**, 2132). His eculations were often startling, but their outcome ade plain repeatedly that they could not be ignored. Through his ponderings on virus and host-cell relationships he was drawn at last to the cancer problem, coming to it with unique views. When the tasks he planned are in time taken up by others, one may hope it will be with something of his own discernment, intensity, and delight.

Green was a shy, warmhearted man whom science emboldened. Patient in act, he was restless in thought, as becomes the discoverer. Jenner and John Hunter would have liked him well.

PEYTON ROUS
The Rockefeller Institute for Medical Research

Robert Tracy Jackson
1861–1948

Robert Tracy Jackson, noted paleontologist and retired Harvard professor, died at his home in Peterborough, New Hampshire, at the age of 87.

He was born July 13, 1861, at Dorchester, Massachusetts. In 1884 he graduated from the Lawrence Scientific School of Harvard with the degree of Bachelor of Science and received his Doctor of Science degree from Harvard in 1889. Three years later he joined the Harvard faculty, where, in 1911, he was named associate in paleontology, and subsequently, Curator of Fossil Echinoderms in the Museum of Comparative Zoölogy.

As a teacher Dr. Jackson was personally interested in his students. Once sensing a genuine and earnest interest, he gave of himself unstintingly. For him, such men were his friends, and he gave and received loyal support, which lasted throughout his life.

During his active years of research, he published numerous scientific papers, among which were those dealing mainly with fossil echinoderms, and larger publications, such as *Phylogeny of the Pelecypods, Localized stages in development in plants and animals,* and perhaps his most monumental work, *Phylogeny of the Echini.* His theory on evolution has been a valuable contribution to advanced science.

In addition to his life's work in science, he maintained a deep interest in horticulture, toward which he spent himself with enthusiasm and pleasure all his life. His garden, begun in his youth at his home in Dorchester, Massachusetts, was filled with a valued collection of plants and shrubs of many kinds. He specialized in the growing of peonies and irises.

From his friend and neighbor, John Richardson, he inherited his rare seedling peonies. These and many other plants he later transferred to his lovely garden in Cambridge, and again after twelve years, to his garden at Peterborough, New Hampshire. His pleasure and enthusiasm in the beauty of his and Mrs. Jackson's garden were untiring, and he never ceased in his delight in the production of a perfect specimen, be it peony, iris, or poppy, or any other plant un his care.

Dr. Jackson was a Fellow of the American Acade of Arts and Sciences, Boston Society of Natural H tory, American Society of Naturalists, Geologi Society of America, and Paleontological Society.

JOSEPH A. CUSHM

Harvard University

Association Affairs

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Chemistry (C): Robert S. Shelton, Wm. S. Merrell Co., Cincinnati
Geology and Geography (E): Raymond C. Moore, University of Kansas
Zoological Sciences (F): H. J. Van Cleave, University of Illinois
Botanical Sciences (G): W. C. Steere, University of Michigan
Psychology (I): Harold E. Burtt, The Ohio State University
History and Philosophy of Science (L): Charles W. Morris, Chicago
Engineering (M): W. R. Woolrich, University of Texas
Medical Sciences (N): Cecil J. Watson, University Hospital, Minnesota
Agriculture (O): Emil Truog, University of Wisconsin
Education (Q): Francis D. Curtis, University of Michigan
(Nominations have not yet been received from the Committees of Sections D, H, and K.)

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Astronomy (D): Charles C. Wylie, University o Iowa, Iowa City, Iowa (1948)
Geology and Geography (E): Leland Horberg, Un versity of Chicago, Chicago, Illinois
Zoological Sciences (F): J. H. Bodine, Universit of Iowa, Iowa City, Iowa
Botanical Sciences (G): Stanley A. Cain, Cranbroo Institute of Science, Bloomfield Hills, Michigan
Anthropology (H): Marian W. Smith, Columbi University, New York, New York (1948)
Psychology (I): Delas D. Wickens, Ohio State Un versity, Columbus, Ohio
Social and Economic Sciences (K): J. Frederic Dew hurst, Twentieth Century Fund, New York, Ne York (1948)
History and Philosophy of Science (L): Raymond J Seeger, Bureau of Ordnance, Navy Department Washington, D. C.
Engineering (M): Frank D. Carvin, Illinois Insti tute of Technology, Chicago, Illinois

Medical Sciences (N), Subsection on Medicine (Nm): Gordon K. Moe, University of Michigan, Ann Arbor, Michigan; Subsection on Pharmacy (Np): Glenn L. Jenkins, Purdue University, Lafayette, Indiana; Subsection on Dentistry (Nd): Isaac Schour, College of Dentistry, University of Illinois, Chicago, Illinois

Agriculture (O): E. E. DeTurk, University of Illinois, Urbana, Illinois

Education (Q): Dean A. Worcester, University of Nebraska, Lincoln, Nebraska

Officers of the Pacific Division:

President: R. E. Clausen, University of California, Berkeley, California

Secretary: R. C. Miller, California Academy of Sciences, Golden Gate Park, San Francisco, California

Officers of the Southwestern Division:

President: Frederic H. Douglas, Denver Art Museum, Boulder, Colorado

Secretary: Frank E. E. Germann, University of Colorado, Boulder, Colorado.

Book Reviews

Lehrbuch der inneren Sekretion. F. Verzár. Liestal, Switzerland: Ars Medici Ludin AG., 1948. Pp. xx + 608. (Illustrated.)

This textbook is an admirable introduction to the rapidly developing and expanding science of endocrinology. Dr. Verzár is a pioneer in this field and is particularly competent to undertake the difficult task of summarizing the methods and results of endocrinology in a relatively brief treatise. The American as well as the European literature is adequately and critically discussed.

It is not always possible to agree with Prof. Verzár as to the relative importance of the material included. For example, in a textbook of barely 600 pages, he devotes over 36 pages to the thymus gland, while secretin and renin get two pages each and enterogastron and cholecystokinin two paragraphs. There is no index.

The comparative physiologist as well as the clinician will profit greatly by this new textbook which could also be safely used as optional reading material in standard medical physiology courses. The book is recommended to all interested in the physiology of internal secretion and in the clinical possibilities of hormone therapy. The German style is lucid and can be easily followed by students acquainted with scientific German. An English translation would be highly desirable.

THEODORE KOPPANYI
Georgetown University School of Medicine

Crop management and soil conservation. (2nd ed.) Joseph F. Cox and Lyman E. Jackson. New York: John Wiley; London: Chapman & Hall, 1948. Pp. xxii + 572. (Illustrated.) $3.80.

Farm soils: their management and fertilization. (4th ed.) Edmund L. Worthen. New York: John Wiley; London: Chapman & Hall, 1948. Pp. xiii + 510. (Illustrated.) $3.20.

These books cover a broad field thinly. By inference, at least, they aim to deal with all agricultural regions of the United States. Actually, the center of attention is the eastern part of the Middle West, with something about the South and the Great Plains, and a bit about the West. Since an appeal is made to both farmers and young students, scientific language and principles are held to the minimum. Partly for this reason, full use is not made of the enormous body of technical knowledge acquired in the past two decades. Thus large parts of the books could be appropriately back-dated some 20 years.

In the book by Cox and Jackson, the first part of the title is treated more nearly adequately than the last. This book could have been recommended for high-school agricultural students if the discussions of soils had been omitted. But not enough helpful material is included on soils to offset the inadequacies.

Even though prepared for vocational agricultural students in high-schools, there can be no excuse for completely omitting the use of modern soil classification and published soil maps in arriving at specific recommendations for individual fields and farms. Again and again the reader is admonished to use crops and practices "adapted" to his soil. This is very good advice. But he is not told what these are nor even how he can find out. In fact, the reader is not even given a working concept of the principal kinds of soil in the United States or how he might learn about those of his own community or farm. One even finds statements like this: "Clay soils are usually poorly drained and hence tilling is necessary for sure production of corn, beans, and beets." Many soil types rich in clay do not need tilling, and many poor in clay do.

Terraces are generally recommended for sloping land. The authors fail to differentiate between those soils on which terraces would be useful and those on which they would be ineffective or even ruinous.

Fertilizer recommendations are exceedingly general—not specific to defined conditions—and are out of date. Little is said about the advantage of high-analysis kinds. For example, in the chapter on growing clover, one finds this: "On run-down and light soils, fertilizers containing potash as well as phosphorus, or complete fertilizers, such as 0-12-6, or a 2-12-4, are recommended." For years, agronomists and soil scientists have condemned such low-analysis materials. The very significant fertilizer and agricultural programs of the Tennessee Valley Authority are not even mentioned.

The part on crops is better but hardly up to date. The new methods for corn growing, involving closer spacing

and supplemental nitrogen fertilization with adapted hybrids, are ignored. Modern methods for weed control with chemical sprays are mentioned but not explained.

Apparently the authors have tried to cover too much too fast. Thus, they avoid specificity, yet specificity is essential in farm management. The result is a mixture of old concepts and comparatively old practices, some good and some mediocre. It is far behind the modern successful farmer.

Farm soils is a more useful book. First of all, the author has confined his attention largely to soil management and thus not attempted to cover so much ground. Yet, relatively, it is less up to date than the earlier editions. Too much old material has been retained and not enough of the new results and new methods explained.

The author's concept of soil management is largely one of maintaining the soil. He writes that "farm soils tend to become acid." More often "farm soils" that need lime were acid at the start. Our problem with lime, organic matter, plant nutrients, and soil structure is, generally, as much or more one of improving the natural soils as it is of maintaining them.

The discussion of soil classification as a basis for predicting yields under alternative practices is outdated by 15 years or more. And even the system presented is not integrated with the recommendations in a way to permit these to be applied to specific conditions.

The moldboard plow is defended almost too much. Under dry-farming in regions of low rainfall he writes: "Therefore, plow to a depth of 7 or 8 inches promptly after crops are harvested." The greatly improved tillage methods now used by good farmers for the Chernozem, Chestnut, and Brown soils are inadequately explained.

This book is much better than *Crop management and soil conservation* on lime and fertilizer. Worthen stresses the savings to be made from home mixing of fertilizers and explains how it is done. He emphasizes the great savings resulting from the use of high-analysis materials rather than low-analysis ones. Yet, one wishes he had gone further and not written that "the 5-10-5, with a total of 20 percent of nitrogen, phosphoric acid, and potash, would class as a high-analysis or a high-grade fertilizer. . . ." But he shows the advantage of really high-analysis kinds. There are little errors such as "complete" for "mixed" fertilizer and "alkali" for "saline" soil. Generalizations are used where published data, if reviewed, would have permitted specificity.

Like the earlier editions, this book has a place for vocational agricultural courses in high schools and junior colleges, particularly in the humid-temperate part of the country. But it will need careful correction and supplementing by the teacher, using local soil surveys and recent bulletins of state agricultural colleges and the U. S. Department of Agriculture.

Two books are badly needed—one in agronomy and one in soil management—that can compare with *Farm management* by Black, *et al.* and *Feeds and feeding* by Morrison. Neither of these comes close to filling this need.

CHARLES E. KELLOGG

U. S. Department of Agriculture,
Beltsville, Maryland

Scientific Book Register

BOUMA, P. J. *Physical aspects of colour: an introduction to the scientific study of colour stimuli and colour sensations.* New York: Elsevier, 1948. Pp. 312. (Illustrated.) $5.00.

COHEN, MORRIS R. *Studies in philosophy and science.* New York: Henry Holt, 1949. Pp. 278. $4.50.

GOLD, HARRY. (Ed.) *Cornell conferences on therapy.* (Vol. 3.) New York: Macmillan, 1948. Pp. xx + 337. $3.50.

WHELPTON, P. K. *Forecasts of the population of the United States, 1945–1975.* (U. S. Dept. Commerce, Census Bureau.) Washington, D. C.: Govt. Printing Office, 1947. Pp. vi + 113. (Illustrated.) $.45.

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NEWS and Notes

James W. McBain, professor emeritus of chemistry at Stanford University, has accepted appointment under the Central Government of India as director of the National Chemical Laboratories of India. The appointment is for an initial period of three years.

Jerome J. Howland, Jr., has become a member of the staff of Chemistry Department of Brookhaven National Laboratory. Dr. Howland has been performing research in nuclear chemistry at the University of California Radiation Laboratory.

H. S. Hulbert and **George Russell Agassiz** have been chosen patrons of the American Astronomical Society. Judge Hulbert was instrumental in the creation of the University of Michigan's McMath-Hulbert Observatory at Lake Angelus, near Detroit. Dr. Agassiz is vice chairman of the Committee to Visit the Department of Astronomy of the Board of Overseers of Harvard College.

Oskar Baudisch of the New York State Research Institute of the Saratoga Spa at Saratoga Springs, New York, is temporarily stationed at the U. S. Plant, Soil, and Nutrition Laboratory at Ithaca, New York, as a consultant in biochemistry. While there, he will conduct research on the relationship of cobalt to nutritional problems.

Thomas Addis, professor emeritus of medicine at Stanford University, is now a member of the Institute for Medical Research at Cedars of Lebanon Hospital, Los Angeles, where he will continue his laboratory investigations into problems related to renal diseases. He will collaborate with Harry Goldblatt, director of the Institute, in studies on the relationship between kidney function and high blood pressure, and with Jessie Marmorsten in studies of adrenal glands as related to the kidneys.

Paul R. Burkholder, Eaton professor of botany at Yale, is making a 15,000-mile trip throughout Latin America to collect soil samples for examination in his search for new antibiotics. The soil will also be analyzed for its agricultural qualities. Last year Dr. Burkholder discovered, in a sample of Venezuelan soil, the mold which makes the drug chloromycetin.

Fred Ordway has become a research associate at the National Bureau of Standards, on the staff of the Portland Cement Association Fellowship.

Herbert F. Traut, professor of obstetrics and gynecology at the University of California Medical School, will deliver the Annual Barnard Lecture at the St. Louis Medical Society Auditorium in St. Louis, Missouri, on February 1. Dr. Traut will speak on "Cytological Diagnosis of Cancer as It Applies to the Female Genital and Pulmonary Tracts."

Visitors to U. S.

Olaf E. Ryberg, lecturer at the Alnarp Institute, Akarp, Sweden, recently visited zoological and entomological laboratories in the United States, and attended the Washington meeting of the AAAS and the New York meeting of the American Association of Economic Entomologists. He will report to the Swedish government on the status of economic zoology and entomology in the U. S.

Albert Szent-Gyorgyi, Hungarian biochemist who won the 1937 Nobel laureate in medicine, is working as a special research fellow at the National Institute of Health, Bethesda, Maryland. Assisting him is **Koloman Laki,** another Public Health Service Fellow, who had worked with Dr. Szent-Gyorgyi at the University of Budapest.

Hideki Yukawa, physics professor at Kyoto Imperial University, and **Shizuo Kakutani,** professor and head of the Department of Mathematics at Osaka University, are now at the Institute for Advanced Study at Princeton, and recently lectured at Carnegie Institute of Technology.

Patrick L. Mollison, of the Postgraduate Hospital in London, England, who is visiting here, recently spoke at Duke University Hospital, on "Survival of Transfused Red Blood Cells."

Grants and Awards

The Oersted Medal of the American Association of Physics Teachers will be awarded Arnold Sommerfeld, 79-year-old German physicist at the Association's annual meeting in New York, January 27–29.

The Ernst Bischoff Company of Connecticut has made available a grant of $1,200 to Brooklyn College, to be used under the direction of Harry G. Albaum of the Department of Biology.

Forty-two Public Health Service Grants totalling $1,498,333 have been awarded to medical schools for developing or expanding undergraduate training in psychiatry. The first funds will be made available for the 1949–50 school year. Subsequent payments will be in annual allotments for the next two school years. In selecting the schools to receive grants, the Council favored those that were not receiving other mental hygiene grants from the Government and had not been able to establish a strong program but had potentialities for doing so.

Eta Kappa Nu, national honor society for electrical engineering, has selected Abe Mordecai Zarem, manager and chairman of physics research of the Stanford University Research Institute at Los Angeles, as the Outstanding Young Electrical Engineer of 1948. Jay Wright Forrester, associate director of the Servomechanisms Laboratory, Massachusetts Institute of Technology, and Milton E. Mohr, of the Bell Telephone Laboratories Technical staff in New York, were selected for honorable mention.

The Kirksville College of Osteopathy and Surgery has received a grant of $8,926 from the National Institutes of Health, U. S. Public Health Service, to continue electromyographic studies of single motor units. Three grants totaling $16,718

were also awarded by the Research Fund of the American Osteopathic Association, to continue studies of reflex activity in the spinal cord, to assist research on morphological variations of the motor end plate and visceral alterations resulting from alterations of the vertebral area, and to continue structural studies of the rural school children in Adair County, Missouri.

The University of Michigan recently announced grants amounting to $26,865 for research by University staff members. The grants, effective January 1, were made available from the Faculty Research Fund and the Horace H. Rackham Fund. H. M. Randall, professor emeritus of physics was awarded $3,000 for a study of the applications of infrared spectroscopy to biological research. A $2,500 grant for an inquiry into neuro-cellular generation of nerve impulses was made to Robert Gesell, chairman of the Department of Physiology in the Medical School. Among the other grants were two of $2,000 each: to Emmet T. Hooper, associate professor of zoology, and Floyd A. Peyton, professor of dentistry.

Fellowships

Applications for the newly created Howard Hughes Fellowships in Creative Aeronautics must be sent to the Dean of Graduate Studies, California Institute of Technology, Pasadena 4, California, before *February 15*, 1949. Open to qualified graduate students, the fellowships carry a stipend of $1,500 or more, plus $1,500 for tuition and research expenses and a salary of $2,000 or more for work at Hughes' Culver City aircraft plant.

The Institute for Numerical Analysis of the National Bureau of Standards, at the University of California, Los Angeles, is offering research fellowships for the summer of 1949 and the academic year 1949–50 to qualified graduate students now enrolled in accredited schools. Fellows will be expected to perform mathematical research aimed at methods for advancing applications of high-speed automatic digital computing machinery. Work done under a fellowship may be applied toward a thesis for an advanced degree. Stipends will be based on annual salaries of $2,294 for master's degree candidates and $3,727 for doctoral candidates. Further information and application blanks may be obtained from the Chief, Institute for Numerical Analysis, 405 Hilgard Avenue, Los Angeles 24, California.

Colleges and Universities

The New York University-Bellevue Medical Center has received a gift "in excess of $8,000,000" from the Samuel H. Kress Foundation. Under terms of the grant, the money will be used to develop a wide program of postgraduate medical education at the Center.

Southern Methodist University, will lay the cornerstone for its $2,000,000 Fondren Hall of Science on February 8. The construction of the all-science building, due to be completed this fall, was made possible by a gift of $1,000,000 from Mrs. W. W. Fondren of Houston, Texas. The building will house the Departments of Biology, Chemistry, Physics, Geology, and Geography.

A pilot plant to produce equilenin, a hormone that may be convertible into the male and female sex hormones, has been set up by the Wisconsin Alumni Research foundation at the University of Wisconsin. The value of equilenin, according to Wisconsin scientists, lies in the fact that it is the only hormone that can be made synthetically from coal tar products. The process being used is the result of basic research begun in 1941 under the direction of William S. Johnson of the University.

Meetings and Elections

The third annual meeting of the American Academy of Oral Pathology will be held at the Stevens Hotel in Chicago, February 6. Robert A. Moore, dean of the School of Medicine and professor of pathology, Washington University, will speak at the evening banquet.

The Kentucky Psychological Association will hold a two-session clinical meeting in Louisville, Kentucky, February 15. A second meeting, devoted to educational psychology and mental hygiene, will take place in Louisville in April, at the time of the Kentucky Education Association Meeting. A third meeting, devoted to research reports and association business, is scheduled on May 21 at the University of Kentucky.

The Section on Microbiology of The New York Academy of Medicine will conduct a symposium on certain aspects of the biology, metabolism, immunity, diagnosis and treatment of the more common parasitic infections Tuesday evening, March 15, and Wednesday after and evening, March 16, at the Academy's headquarters, 2 East 103 Street, New York City.

The American College of Physicians will hold its 30th annual session March 28 through April 1 in New York City. Dr. Franklin M. Hanger, Jr., of New York City, is acting as chairman for local arrangements and the program of clinics and panel discussions, while the president of the College, Dr. Walter W. Palmer, director of the Public Health Research Institute of the City of New York, Inc., will be in charge of the program of morning lectures and afternoon general sessions.

The Sixth Western Metal Congress and Western Metal Exposition will be held in Los Angeles April 11–15, under the management of the American Society for Metals. A technical program on all phases of metal science is being developed in cooperation with the western sections of 5 other national technical societies. Latest developments and techniques will be displayed by manufacturers of basic materials, as well as processors of all types of industrial products. Further information may be obtained by writing to the American Society for Metals, 7301 Euclid Avenue, Cleveland 3, Ohio.

The 1949 Conference of Corrosion Engineers will be held April 11–15 in Cincinnati, Ohio. Forty-two technical papers will be presented at 5 symposia, on corrosion principles, chemical industry, electrical and communications industries, cathodic protection, pulp and paper industry, general industry, transportation indu

..., protective coatings, oil industry, ... water corrosion, and gas industry.

The Society of American Bacteriologists will hold its 1949 annual meeting May 16–20 in Cincinnati, Ohio. Walter J. Nungester, University of Michigan, will act as chairman of the program Committee; while Merlin L. Cooper, Cincinnati General Hospital, will serve as chairman of the Cincinnati Local Committee in charge of the meeting.

Recently elected officers of the Society for the 1949 term are: Wm. McD. Hammon, Hooper Foundation, San Francisco, president; Barnett Cohen, Johns Hopkins University, vice-president; and John E. Blair, Hospital for Joint Diseases, New York City, secretary-treasurer.

The Fourth International Conference of the International Association of Quaternary Research will meet in Budapest August 22–September 15. Students of Pleistocene research—stratigraphy, anthropology, paleontology, geomorphology—are invited to attend. Two excursions, one to western Hungary and one to eastern Hungary, will be made. Full particulars may be obtained from the Hungarian Committee for INQUA IV, Hungarian Geological Institute, XIV Vorosilov-ut 14, Budapest.

The American Anthropological Association held its 47th annual meeting at the University of Toronto and the Royal Ontario Museum of Archaeology on December 28–30. Its newly elected officers are: A. Irving Hallowell, University of Pennsylvania, president; Harry Hoijer, University of California, Los Angeles, vice president; and John O. Brew, Peabody Museum, Harvard University, and Morris E. Opler, Cornell University, Executive Board members. Melville Herskovits, Northwestern University, took office as editor of the *American Anthropologist* beginning with 1949.

The Division of Biological Chemistry of the American Chemical Society has elected as chairman John T. Edsall, associate professor of biological chemistry at Harvard University. He succeeds Erwin Brand of the Columbia University biochemistry department. Jules D. Porsche, assistant director of the chemical research and development department of the Armour Laboratories, Chicago, was named vice-chairman and Paul W. Preisler, associate professor of biological chemistry at Washington University, was chosen secretary, succeeding Dr. Edsall.

The Botanical Society of Washington has elected the following officers for 1949: Roland Bamford, president; H. A. Borthwick, vice-president; A. V. P. Smith, recording secretary; Vivian K. Toole, corresponding secretary; Wilbur D. McClellan, treasurer; and E. L. LeClerg and R. L. Weintraub, counsellors. John A. Stevenson was made archivist, and Freeman Weiss was nominated as representative to the Washington Academy of Sciences.

The Ninth General Conference on Weights and Measures

The General Conference on Weights and Measures, established in 1875 by the treaty known as the Convention of the Meter, held its ninth session in Sèvres, France, October 12 to 21, 1948. The regular interval between meetings of this Conference is six years, but the series of meetings had been interrupted by the war and no sessions had been held since 1933.

At its inaugural meeting the Conference was received by M. Robert Schuman in the historic Salon de l'Horloge at the Ministry of Foreign Affairs. The regulations provide that the President of the Academy of Sciences of Paris shall serve as President of the Conference. M. Henri Villat, the present President of the Academy, presided at some of the sessions. M. Louis de Broglie, Permanent Secretary of the Academy and head of the French delegation in the Conference, presided at others.

The Conference included fifty-five delegates appointed by twenty-eight of the governments which belong to the organization. Only five states had not sent delegates, two among them because they do not now have governments.

The International Committee on Weights and Measures, whose members are elected by the Conference, serves as a technical committee for the Conference. The Committee in turn is assisted by three special Advisory Committees dealing respectively with electricity, photometry, and thermometry and calorimetry. The International Bureau of Weights and Measures at Sèvres constitutes a permanent central office and laboratory for the Conference and the Committee.

A general report on the activities of the International Bureau during the past fifteen years was presented by the President of the International Committee, Mr. J. E. Sears of Great Britain. The Conference was then called upon to sanction the principal metrological results obtained during these fifteen years, including the final operations of the first periodic verification of national prototype meters and current determinations in the second periodic verification of the national prototype kilograms. With the exception of two kilograms which were well known to have been slightly reduced by wear, the new values reported to the Conference, both for the meters and for the kilograms, differed from the original values of 1889 only by amounts less than the possible errors of measurement involved. The historic "Kilogram of the Archives" was also included in these comparisons and showed a diminution of 0.4 milligram, which was not surprising in view of the character of the material from which it was made.

The idea of substituting a wavelength of light for the bar of platinum iridium which has been, and still is, the basic standard of length, is not new. However, this idea received at this meeting important support by the reports on production of elements consisting of a single isotope. These were mercury of mass 198 obtained in the United States by bombardment of gold 197 and in Sweden by electromagnetic methods of separation, and also krypton of masses 84 and 86 obtained in Germany with a purity of 99.9 per cent. By using these materials of single atomic mass one should be able to obtain spectral lines especially fine and of well-defined wavelength. The experiments reported confirmed this expectation but indicated that further studies will be necessary before one can consider making the change in the basic

standard of length. The Conference reached this conclusion.

In view of the very large number of measurements which are being made of relative values of gravity, a determination of the absolute value of this quantity has assumed large importance. Preparations are being made at the International Bureau to make this determination by observations on a falling body in place of the pendulum which has served in all previous determinations. The Soviet and the Spanish delegations presented at the Conference similar proposals giving active support to this work.

The International Committee decided in 1946 to arrange for the introduction in all countries simultaneously on January 1, 1948, of absolute electrical units to replace the previously used international units. It likewise arranged for the substitution of a single unit of intensity of light, the "candela" (previously called "bougie nouvelle" or "new candle"), based on the brightness of a black body, in place of the former units, the international candle and the hefner. These actions of the Committee were confirmed by the General Conference.

In meetings which preceded the Conference and prepared proposals for it everybody was found to be in accord on the adoption of the joule as the basic unit of heat, but some physical chemists wished to retain the calorie, and the relation of that unit to the joule presents a difficult question. The decision on this point adopted by the Conference was to ask only that those who still use the calorie shall give with their results all the information necessary to convert their results to joules.

Important changes of principle affecting the thermometric scale were accepted. The triple point of water is to replace the melting point of ice as the first fundamental fixed point, and it is forecast that the absolute zero in the Kelvin scale will be substituted for the boiling point of water as the second fundamental point. The International Temperature Scale which has been in course of development for so many years by the collaboration of the great national laboratories arrived this time at such a state that the qualification "provisional" is dropped. Temperatures in this scale are designated by "°C" or "°C (Int. 1948)" and the name of "Celsius" was adopted to replace the terms "centésimal" and "centigrade."

The most difficult question with which the Conference had to deal was one which troubles many men of different disciplines and many engineers, namely, the question of a practical international system of units. This question was presented to the Conference by the International Union of Physics, but the Conference did not feel able to settle it immediately, particularly because it did not have at hand sufficient information. The Conference, therefore, made no decision further than to charge its International Committee to undertake an official inquiry through the medium of the embassies and legations of the various countries which will be asked to report the opinions held in each country in scientific, technical, and educational circles on this question. As a base of discussion there was presented a detailed document prepared by the National Scientific and Permanent Bureau of Weights and Measures of France.

Undoubtedly in the fifteen years now passed in review the metric system has made considerable progress, but the agenda of the Conference was too full to permit presentation of the reports on this subject by different delegations and the International Bureau. Those interested are, therefore, referred to the article on this subject which will appear in the Proceedings of the Conference.

The International Union of Physics had published a list including a very large number of symbols, or abbreviations, which it recommended for magnitudes and for units. The Conference accepted only the list of symbols relating to units, with the exception of one, the atmosphere.

For the names of large numbers, the Conference recommended that countries in Europe, such as Belgium, Spain, France, Italy, Sweden, and Switzerland, abandon their present usage and adopt uniformly the practice of other countries, which seemed perhaps a little more logical. This other practice may be represented by the mnemonic formula $10^{6N} = (N)$ illion, according to which a billion is a million millions, a trillion is a million billions, etc. It was recommended also that numbers written in groups of three digits should have only a space between successive groups of three, the comma (according to French usage) or the period (according to British usage) being reserved to serve as a decimal point.

It is evident from the preceding account that the Ninth General Conference had a large amount of work to do. The discussions at the meetings took place in an atmosphere of reciprocal scientific understanding which developed more and more in the course of the sessions. It may be of interest only to note a slight incident which arose through the presentation of a motion by one of the delegations at the first working session looking to the exclusion of another delegation. The reasons advanced, which were of political nature, were easily cleared away in individual discussions and no further questions of this kind were raised. (*Translated from a short report by Albert Pérard, director of the International Bureau of Weights and Measures.*)

Deaths

Howard S. Fawcett, 71, authority on citrus diseases and professor emeritus of plant pathology at the Citrus Experiment Station, University of California, died December 12 at the Community Hospital, Riverside, California. Dr. Fawcett wrote the text *Citrus diseases and their controls* and contributed many articles to scientific journals. A charter member of the American Phytopathological Society, he received its highest honor in 1930 by election to presidency of the national group.

Raymond C. Martinelli, 34, associate professor of mechanical engineering at the University of California, died in Oakland, California January 9. Since 1946 Dr. Martinelli had done research for the Heat Transfer Section, Atomic Power Division of General Electric.

Gordon E. Richards, 63, professor of radiology at the University of Toronto, director of the Ontario Institute of Radiotherapy, and director of radiology at the Toronto General Hospital, died January in Toronto, Canada.

R. L. Jones, 62, vice president of the Bell Telephone Laboratories, and former director of apparatus development, died January 14 at his home in Summit, New Jersey.

Charles A. Marlies, 43, associate professor of chemical engineering at CCNY, engineering consultant, and author of the recently published *Principles of the high polymer theory*, died January 14 in New York City.

Harry Stack Sullivan, 56, psychiatrist and author, died in Paris, France, January 15, while enroute home from a charter meeting of the World Federation for Mental Health held in Amsterdam. Dr. Sullivan had served as editor of the journal *Psychiatry*, president of the William Alanson White Psychiatric Foundation of Washington, D. C., and director of the department of psychiatry, Georgetown University Medical School.

Josiah Charles Trent, 34, assistant professor of surgery at Duke University School of Medicine and chief of thoracic surgery, died December 10 at Durham, North Carolina. Dr. Trent was recognized for his writings and collection of books on medical history.

The Edwin Smith Surgical Papyrus, the oldest record of scientific medical knowledge in the world, has been recently presented to the New York Academy of Medicine by the New York Historical Society and the Brooklyn Museum. The 3,600-year old transcription of a medical treatise written more than 1,000 years earlier, was discovered in Luxor, Egypt, by Edwin Smith, a student of Egyptology, who recognized its importance to medical history. Following Mr. Smith's death in 1906, the papyrus was presented to the New York Historical Society by his daughter.

Written in ancient hieratic style, the text of the papyrus had first to be reproduced in hieroglyphics before an English translation could be made. This work was accomplished by the late James Henry Breasted of the University of Chicago, and published in 1930 in two volumes. One volume contains a facsimile in color of the entire papyrus, the other Dr. Breasted's translation and comments. The volumes, as well as the original papyrus, have been presented to the Academy by the Society and the Museum.

The author of the papyrus, whose name is unknown, was a physician who lived approximately 5,000 years ago when the Pyramids were being erected, and whose professional authority was so great that his works continued to be a scientific guide for medical practise for several millenia, according to Dr. Breasted. The papyrus deals entirely with surgery in a series of 48 illustrative cases and obviously records only part of the original treatise. The author's knowledge of anatomy was founded on human dissection and he already knew that blood flowed from the heart through the blood vessels to all parts of the body.

Through the International Exchange Program of the Department of State, given Congressional recognition by passage of the Mundt-Smith act on January 27, 1948, the U. S. Government now serves as a focal point in negotiating with other nations in the field of scientific and educational exchange. Office of Educational Exchange, established April 22, 1948.

The Division of International Exchange of Persons assists persons moving to and from this country for scholastic purposes and carries out Department responsibilities for certain programs involving the use of Government funds for the exchange of students, trainees, professors, research specialists, teachers, and lecturers. It also deals with the assignment of foreign specialists to certain projects and reviews requests for the loan of U. S. Government technicians made by foreign governments.

The Division of Libraries and Institutes augments the work of educational exchange by the dissemination of books, by maintaining libraries overseas, and by assisting U. S.-sponsored educational institutes abroad. The libraries make available American printed matter and library facilities, such as bibliographic and reference services, to foreign officials, scholars, writers, professors, and the general public. They maintain staff services for Foreign Service and the U. S. Information Service abroad.

The Interdepartmental Committee on Scientific and Cultural Cooperation is the coordinating unit for the educational exchange program. This Committee keeps advised of scientific and technical resources developed within this Government and assists other countries seeking advice on such subjects as agriculture, archival sciences, coast and geodetic surveying, fishery development, industrial research and standardization, library science, mining, metallurgy, and wildlife resource. Foreign governments contribute to the maintenance of these projects.

The University Maria Curie-Sklodowska, Lublin, Poland, is publishing the results of its scientific investigations in a series of volumes entitled *Annales Universitatis Mariae Curie-Sklodowska.* The annals comprise papers in natural science and related branches and are divided into the following sections: A—Mathematics, Physics and Chemistry; B—Geography, Geology, Mineralogy and Petrography; C—Biology; D—Medicine; E—Agriculture; F—Philosophy and Humanities. One volume of each section will be published each year, and several are now in print. Further information may be obtained by writing to the University, Plac Litewski 5, Lublin, Poland.

A report on Mental Hygiene Statistics, the first in a forthcoming series to be designated as the MH-S series, has been issued by the Division of Mental Hygiene, Public Health Service, Federal Security Agency, Washington 25, D. C. Statistics cover the normal capacity, percentage of overcrowding, full-time administrative staffs and expenditures for the maintenance of state hospitals for mental disease in 1946 by states and divi-

sions of the U. S. The MH-S series will make available the results of the annual *Survey of Patients in Mental Institutions* prior to the publication of a consolidated final report.

The radioisotope training facilities of the Oak Ridge Institute of Nuclear Studies have been opened to a limited number of scientists who are citizens of nations qualified to receive radioisotopes under the Commission's isotope export program.

The first foreign scientists selected for the program are K. Aterman, Department of Anatomy, University of Birmingham, England, and P. S. Krishnan of Madras, India.

A report on German wartime advances in infrared technology, available through the Office of Technical Services, Department of Commerce, reveals some German developments in the infrared field beyond those accomplished in the U. S. during the war. In concentrating on military applications, the Germans also perfected devices for photography, spectroscopy, and other uses promising wide industrial applicability. The report, PB 95308, *German War-Time Developments in Infra-red*, by T. M. Odarenko, was prepared in cooperation with University Laboratories, New York, and sells for $3 a copy. Orders should be addressed to the Office of Technical Services, Department of Commerce, Washington 25, D. C., accompanied by check or money order payable to the Treasurer of the United States.

The Optical Society of America has sponsored arrangements for two speaking tours among some of its local sections. On May 23, David Richardson, of the Bausch and Lomb Optical Company, will address the Detroit, (Michigan) Section on the topic, "The Ruling and Testing of Diffraction Gratings." Gordon F. Hull, Jr., of Dartmouth College, will give his lecture, "Microwave and Optical Analogues," before the Rochester (New York) Section on March 29, the Niagara Frontier Section on March 30, and the Detroit Section on April 1.

The search for emission B stars and planetary nebulae in the Milky Way, begun on Mt. Wilson thirty years ago, will be completed in South Africa during the next 3 years. The Palomar Observatories are loaning their 10-inch refractor telescope to the University of Michigan's Lamont-Hussey Observatory at Bloemfontein, South Africa for the survey, which will be carried on under the direction of Leo Goldberg, director of the University of Michigan Observatory. All of the Milky Way that can be photographed from Mt. Wilson has now been surveyed with red-sensitive plates and the remaining part will be studied from the Dark Continent.

An expedition under the direction of Archaeologist Axel W. Persson, of Upsala University, Sweden, will explore ruins of the town of Labranda, in Asia Minor, this summer. The ruins date from about 400 B. C. Professor Persson's aim is to establish a connection between Labranda's culture and that of the Minoan era in Crete, which ended about 1400 B. C. A Swedish government grant will aid the expedition.

The *Journal of the American Society of Agronomy* is now being issued under a new name, *Agronomy Journal*, which was adopted on January 1, coincident with the resignation of J. D. Luckett, editor of both the *Journal* and the *Proceedings of the Soil Science Society of America* for many years. His successor is Maurice R. Haag, formerly Experiment Station editor for the University of Wyoming. The editorial offices have been moved from Geneva, New York, to Madison, Wisconsin.

Make Plans for—

9th Pittsburgh Conference on Applied Spectroscopy, sponsored by Spectroscopy Society of Pittsburgh, February 18–19, Mellon Institute Auditorium, Pittsburgh, Pennsylvania.

Metropolitan Microchemical Society of New York, symposium, February 25–26, American Museum Natural History, New York City.

Research Conference on Cocc osis of the New York Academy Sciences, March 3–4, American seum of Natural History, New Y City.

Recently Received—

A study of line intensities in the sp tra of four solar-type stars, by K. Wright. (Publ. Dominion As physical Observatory, Victoria, B. Vol. VIII, No. 1.) Ottawa: E mond Cloutier, 1948. $.25.

Intensities of molecular bands in spectra of three early R-type st by Andrew McKellar and Willi Buscombe. (Publ. Dominion As physical Observatory, Victoria, C., Vol. VII, No. 24.)

You and your future at Aberd Proving Ground. Information ab position openings obtainable fr Civilian Personnel Division, Ab deen Proving Ground, Maryland.

Report of the Naval Ordnance Labo tory, November 1948.

Cenco News Charts, No. 62. Publish by Central Scientific Company, C cago, Illinois, and featuring article about the American Chem Society.

Highlights. Published by the Eastm Kodak Company, Rochester, N York, and summarizing current n and information of interest shareholders and friends of the C pany.

Farm & Home Science. Publish quarterly by the Utah Agricultu Experiment Station.

Social Science Research Council Ite Contains Council news and spec social science articles.

Dow Corning Silicone Note Bo (Fluid Series No. 3). Illustrat booklet issued by the Dow Corni Corporation, Midland, Michigan.

A survey of pumping in Illino (Highway Research Board Resear Report No. ID.) Washingto D. C.: 2101 Constitution Aven 1948.